



AMSAA

TECHNICAL REPORT NO. 323

USER AND ANALYST MANUAL FOR A FORTRAN COMPUTER PROGRAM
SIMULATING THE ENGAGEMENT OF A STATIONARY POINT TARGET
BY A STATIONARY DIRECT FIRE WEAPON

DTIC QUALITY INSPECTED 2

BERNARD N. GOULET

TECHNICAL
LIBRARY

DECEMBER 1980

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ABERDEEN PROVING GROUND, MARYLAND

DISPOSITION

Destroy this report when no longer needed. Do not return it to the originator.

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position unless so specified by other official documentation.

WARNING

Information and data contained in this document are based on the input available at the time of preparation. The results may be subject to change and should not be construed as representing the DARCOM position unless so specified.

TRADE NAMES

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. The report may not be cited for purposes of advertisement.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report No. 323	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) USER AND ANALYST MANUAL FOR A FORTRAN COMPUTER PROGRAM SIMULATING THE ENGAGEMENT OF A STATIONARY POINT TARGET BY A STATIONARY DIRECT FIRE WEAPON		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Bernard N. Goulet		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Director US Army Materiel Systems Analysis Activity Aberdeen Proving Ground, MD 21005		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA Project No. 1R765706M541
11. CONTROLLING OFFICE NAME AND ADDRESS Commander US Army Development & Readiness Command 5001 Eisenhower Ave., Alexandria, VA 22333		12. REPORT DATE December 1980
		13. NUMBER OF PAGES 115
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) User/Analyst Manual Weapon Effectiveness Probabilities of Hit, Kill FORTRAN Program Direct Fire Rounds to Hit, Kill Simulation Antiarmor Weapons Combat Simulation Tank Main Armament Computer Simulation Infantry Antiarmor Weapons		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report documents a FORTRAN computer program usable to make effectiveness calculations for weapons that fire aimed rounds one at a time against point targets. The program is applicable to tank main guns and infantry antitank weapons engaging tanks, armored personnel carriers, and other such targets. Monte Carlo techniques are used to simulate the engagement, which does not involve any firing by the target. The required inputs include rate of fire, delivery accuracy, and reliability data for the firing weapon, as well as detailed vulnerability data for the target. Other parameters that must be		

20. Abstract - Continued

specified are the range, the target orientation and degree of exposure, and the aimpoint. The outputs are hit and kill probabilities for up to 15 rounds, average number of rounds needed for a target hit or kill, as well as hit and kill probabilities for engagement times up to 2 minutes.

ACKNOWLEDGEMENTS

Contributions to the development of the computer program documented in this report were made by the following:

Oklahoma State University Field Office
Eglin Air Force Base, Florida

G. Spradling
A. Peebles

Army Armament Materiel Readiness Command
Rock Island, Illinois

H. Michels

Ballistic Research Laboratory
Aberdeen Proving Ground, Maryland

H. Ege

Army Materiel Systems Analysis Activity
Aberdeen Proving Ground, Maryland

L. Bain
L. Pitts

CONTENTS

	<u>PAGE</u>
1. INTRODUCTION.	7
2. BASIC DEFINITIONS	9
2.1 Introduction	9
2.2 Firing Engagement.	9
2.3 Engagement Time.	10
2.4 Orientation.	10
2.5 Exposure	10
2.6 Reliability.	10
2.7 Delivery Accuracy.	10
2.8 Hit Probability.	11
2.9 Firing Occasion.	11
2.10 Fixed Bias	11
2.11 Variable Bias.	11
2.12 Random Error	11
2.13 Lay Error.	11
2.14 Round-to-Round Error	11
2.15 Sensing.	11
2.16 Sensing Probability.	12
2.17 Sensing Error.	12
2.18 Target Vulnerability	12
2.19 Kill Probability	12
2.20 Kill (Damage) Criterion.	12
2.21 K, M, F, M Or F.	12
2.22 K Kill	12
2.23 M Kill	13
2.24 F Kill	13
2.25 M Or F Kill.	13
2.26 Kill Probability for Specified Number of Rounds Fired.	13
2.27 Average Number of Rounds Needed to Kill Target	13
2.28 Expected Personnel Casualties.	14
2.29 Rate of Fire	14
2.30 First Round Firing Time.	14
2.31 Flight Time.	14
2.32 Subsequent Round Firing Time	14
2.33 Fixed Time	15
2.34 Variable Time.	15
2.35 Median Time.	15
2.36 Variability Factor	16
2.37 Minimum Time	16
2.38 Kill Probability for Specified Engagement Time	16

CONTENTS

	<u>PAGE</u>
3. GENERAL FLOW OF PROGRAM LOGIC.	17
3.1 Introduction.	17
3.2 Principal Program Steps	17
3.3 Program Steps for Single Engagement at Particular Angle.	18
3.4 Special Options	19
4. INPUT DATA	20
4.1 Introduction.	20
4.2 Card Inputs	20
4.3 Tape or Disc Inputs	27
4.4 Requirements for Special Options.	32
5. OUTPUT DATA.	36
5.1 Introduction.	36
5.2 Outputs of Sample Computer Run.	36
6. COMPUTER ASPECTS	43
APPENDIX A: PROGRAM LISTING AND DETAILED EXPLANATIONS . .	44
APPENDIX B: EXPLANATIONS OF PROGRAM STATEMENTS 919 THROUGH 1131.	90
DISTRIBUTION LIST.	111

Next page is blank.

USER AND ANALYST MANUAL FOR A FORTRAN COMPUTER PROGRAM
SIMULATING THE ENGAGEMENT OF A STATIONARY POINT TARGET
BY A STATIONARY DIRECT FIRE WEAPON

1. INTRODUCTION

This report describes a computer program developed under the sponsorship of the Joint Munitions Effectiveness Manual Surface-to-Surface (JMEM-SS) Methodology and Evaluations Working Group, with a substantial contribution by the Army Materiel Systems Analysis Activity (AMSAA). The program has been used by JMEM-SS and AMSAA to make effectiveness calculations for armor and infantry weapons engaging tanks, armored personnel carriers, and other targets. It utilizes Monte Carlo techniques to simulate the engagement and has been based, to a large extent, on a similar deterministic program previously developed by AMSAA. An earlier version of the JMEM-SS direct fire program has been documented in 1976 by the then US Army Armament Command (Reference 1).

The JMEM-SS direct fire program provides a method for calculating the effectiveness of weapons that fire aimed rounds one at a time against point targets. Such weapons include tank main guns and infantry antitank weapons. The required input includes performance parameters related to the rate of fire, delivery accuracy, and reliability of the firing weapon. A detailed target description and data indicating vulnerability of the target to the type of round fired are also part of the input. Other influencing factors specified for a particular calculation are the range, the orientation of the target, whether the target is fully exposed or only partly exposed, and the aimpoint. To simulate a single engagement, the computer determines the effects of the first round, taking into account several kill criteria of interest. Then, as necessary, second and succeeding rounds up to a limit of 15 rounds are evaluated. Although this limit is a practical one for the calculations, it clearly exceeds the number of rounds normally fired in real combat engagements. The calculations for the first engagement result in an actual possible outcome being established. For example, the target might be determined to be hit on the third round 38 seconds after the start of the engagement. Similar specific numerical values are also assigned to the round number and time corresponding to the target being killed for each kill criterion of concern. The process is repeated until 10,000 engagements have been considered, and data for all engagements are combined to give plausible outputs not unduly influenced by particular engagements. Outputs are:

¹Michels, Herman W., An Analyst/User Manual for the Direct Fire Computer Program, DRSAR/SA/R-18, May 1976, US Army Armament Command, Rock Island, IL, 61201.

a. Hit probabilities and kill probabilities corresponding to various numbers of rounds fired.

b. Average numbers of rounds needed to hit or to kill the target.

c. Hit probabilities and kill probabilities for various engagement times up to a practical limit, established as 2 minutes for the calculations.

The engagement simulated by the direct fire program is restricted to being one-sided. This means that the firing weapon is not subjected to return fire from the target or some other opposing element.

This report has been prepared primarily for users and analysts with an interest in documentation far exceeding in scope the very general explanations in this introduction. The material included is as follows:

- a. Basic definitions (section 2).
- b. General flow of program logic (section 3).
- c. Input data (section 4).
- d. Output data (section 5).
- e. Computer aspects (section 6).
- f. Program listing and detailed explanations of program statements (Appendixes A and B).

Input data used to exercise the JMEM-SS direct fire program as well as outputs of the calculations frequently require a CONFIDENTIAL classification. To make this user and analyst manual UNCLASSIFIED, input and output data not bearing any identifiable relation to classified information have been fabricated to illustrate inputs and outputs associated with the program.

The direct fire program contains some options that are of little or no concern to most users or analysts. These options are identified in this report but not necessarily discussed thoroughly. If a need for detailed explanations concerning any program option arises, these can be provided by AMSAA upon request.

2. BASIC DEFINITIONS

2.1 Introduction.

This section contains definitions, as well as related assumptions and explanations, intended to clarify the meaning of terms used in this report. The following terms are covered:

Firing Engagement (2.2)	K Kill (2.22)
Engagement Time (2.3)	M Kill (2.23)
Orientation (2.4)	F Kill (2.24)
Exposure (2.5)	M Or F Kill (2.25)
Reliability (2.6)	Kill Probability for Specified Number of Rounds Fired (2.26)
Delivery Accuracy (2.7)	Average Number of Rounds Needed to Kill Target (2.27)
Hit Probability (2.8)	Expected Personnel Casualties (2.28)
Firing Occasion (2.9)	Rate of Fire (2.29)
Fixed Bias (2.10)	First Round Firing Time (2.30)
Variable Bias (2.11)	Flight Time (2.31)
Random Error (2.12)	Subsequent Round Firing Time (2.32)
Lay Error (2.13)	Fixed Time (2.33)
Round-to-Round Error (2.14)	Variable Time (2.34)
Sensing (2.15)	Median Time (2.35)
Sensing Probability (2.16)	Variability Factor (2.36)
Sensing Error (2.17)	Minimum Time (2.37)
Target Vulnerability (2.18)	Kill Probability for Specified Engagement Time (2.38)
Kill Probability (2.19)	
Kill Criterion (2.20)	
K,M,F,M Or F (2.21)	

2.2 Firing Engagement.

The firing of one or more rounds at a target. Although combat is generally two-sided, engagements simulated in the direct fire program are only one-sided in that the firing weapon is not itself subjected to any fire. It is assumed that neither the target nor the firing weapon changes its position during the engagement. An engagement begins when the decision is made to fire at the target with a particular type of round. The engagement ends when either the target is killed or 15 rounds have been fired. This limit has been established for the calculations to ensure obtaining all data of possible interest. It is realized this limit exceeds the number of rounds available in the ready rack of tanks. Firing engagements in combat could sometimes be deliberately ended for reasons not represented in the computer simulation program. For example, an armored force might have a policy whereby each tank fires no more than some specified number of rounds, like three, at any particular target in certain situations.

2.3 Engagement Time.

Time elapsing from the beginning of the firing engagement. Engagement time increases as the program calculations account for more and more specific events, for example, the firing of the first round and the arrival of this round at the target range. Engagement time can, but does not always, mean the time needed for the entire engagement to be completed.

2.4 Orientation.

The view that the target presents to the firing weapon. Orientation is specified as an angle with 0 degrees representing the front view, 180 degrees the rear view, and 90 and 270 degrees the side view from two opposite directions. Other orientations are represented by angles from 0 to 180 degrees or from 180 to 360 (same as 0) degrees. An observer facing the target and located on the circumference of a circle with the target at its center should move to the right to see the target at orientations of 0 to 180 degrees, and to the left for orientations exceeding 180 degrees.

2.5 Exposure.

Whether the maximum possible target area or only a portion of the maximum area is presented, for a particular orientation, to the firing weapon. Two exposures are normally considered in applications of the direct fire program:

- a. Open Exposure: The target presents its maximum presented area for a particular orientation.
- b. Defilade Exposure: This condition has been applied only to tank targets. Defilade, or hull defilade, applies to the condition where a tank target presents only its turret as the target. The orientation specified applies to the turret and not the hull since the hull is shielded.

2.6 Reliability.

A measure of the ability of a round to function properly when it is fired and of the fuze to function properly upon impact. Proper functioning basically refers to the absence of catastrophic malfunctions affecting flight of the projectile or fuze action.

2.7 Delivery Accuracy.

A measure of the ability of rounds to hit a target. Delivery accuracy data applying to first rounds and data for subsequent rounds are both needed for the direct fire program calculations.

2.8 Hit Probability.

The chance that, under specific conditions, a target is hit.

2.9 Firing Occasion.

The firing of a small, continuous sequence of rounds at a particular target.

2.10 Fixed Bias.

Errors of the weapon-ammunition-fire control system which are usually constant and predictable at any given range, and are fixed for all firing occasions by the system design. Although the term fixed bias may refer to an individual error, it is used in this report only for the aggregated fixed bias error, in each of the horizontal and vertical directions, that accounts for all applicable individual error sources.

2.11 Variable Bias.

Errors whose values remain very nearly constant during a particular firing occasion, but which may vary considerably from occasion to occasion. Term is used in this report only for the aggregated horizontal or vertical variable bias accounting for all contributing error components.

2.12 Random Error.

Errors or an error whose magnitude and direction vary randomly from round to round even during a single firing occasion. The direct fire program explicitly involves the lay error and the round-to-round error, in each of the horizontal and vertical directions, rather than aggregated random errors.

2.13 Lay Error.

Random error associated with the fine lay made by the gunner before firing.

2.14 Round-to-Round Error.

Random error resulting from differences between individual rounds.

2.15 Sensing.

Process whereby sufficient information concerning the trajectory of a missing round is obtained by the gunner, or by the commander with transmittal to the gunner, as a basis for adjustment of fire before firing of the next round. Sensing is applicable to unguided rounds only.

2.16 Sensing Probability.

The chance that sensing occurs as a basis for adjustment of fire on the next round.

2.17 Sensing Error.

The difference between the weapon aimpoint associated with a missing round that is sensed and the new aimpoint following adjustment of fire. Such differences account not only for incorrect judgments about where missing rounds went and possibly inaccuracies arising from transmittal of information from the commander to the gunner, but also for any errors made by the gunner in relaying as part of the fire adjustment process. The sensing error in each of the horizontal and vertical directions is of concern for the direct fire program calculations involving unguided rounds.

2.18 Target Vulnerability.

A measure of the target's susceptibility to sustain a given amount of damage when hit by a round.

2.19 Kill Probability.

The chance that a target is killed as a consequence of damage sustained. The word kill acquires a definite meaning when it is associated with a specific kill criterion.

2.20 Kill (Damage) Criterion.

The function or functions that a target must lose to be considered out of action. A target killed in one engagement could be repaired and participate in a subsequent engagement.

2.21 K, M, F, M Or F.

Symbols representing four kill criteria whose specific definitions have been used, by the United States and several other countries, as the basis for vulnerability analyses of armored vehicles.

2.22 K Kill.

A target vehicle is subjected to a K kill (complete destruction) if it sustains both an M kill and an F kill and is damaged to the extent that it is not economically repairable. A K kill is more likely to be apparent to the crew of the firing weapon than any other kill because of resulting fires and/or detonation of ammunition.

2.23 M Kill.

A target is subjected to an M kill (mobility) if it is incapable of executing controlled movement and the damage is not repairable by the crew on the battlefield. The loss of this function may be caused by either incapacitation of the crew or damage to the propulsion or control equipment. A target that is M killed could sustain other types of damage at the same time, i.e., F kill or K kill.

2.24 F Kill.

A target is subjected to an F kill (firepower) if it is incapable of delivering controlled fire from the main armament and the damage is not repairable by the crew on the battlefield. The loss of this function may be caused by either incapacitation of the crew or damage to the main armament and its associated equipment. A target that is F killed could sustain other types of damage at the same time, i.e., M kill or K kill.

2.25 M Or F Kill.

A vehicle is subjected to an M or F kill if it sustains either an M kill or an F kill, or both an M kill and F kill. A target that sustains an M or F kill could also at the same time sustain a K kill.

2.26 Kill Probability for Specified Number of Rounds Fired.

Probability that the target is killed when a specific number of rounds, say N, are fired. This probability is meaningful only in conjunction with a kill criterion. N is considered to equal 1 through 15 for the program calculations. The kill probability associated with N rounds is an aggregated result that accounts for kills caused by any round up to and including the Nth round. When N equals 2, the second round is fired only when the first does not kill the target. More generally, any round after the first is fired only when the target has not already been killed.

2.27 Average Number of Rounds Needed to Kill Target.

The average number of rounds needed to kill a target is the arithmetic average of the number of rounds needed to achieve a specified type of kill given an unlimited number of individual firing engagements. Although engagements are not continued beyond 15 rounds, the program calculations account for additional rounds needed in exceptional instances where the target may survive 15 rounds. It is not implied by this that such large numbers of rounds would be involved in an actual combat engagement.

2.28 Expected Personnel Casualties.

Refer to the average, or expected, number of personnel casualties sustained by the troops carried in an armored personnel carrier target. Crew members are excluded. Calculations of personnel casualties have been based on the assault --- 5-minute criterion, which means a man must be rendered incapable of performing an assault role within 5 minutes after being wounded in order to be considered a casualty.

2.29 Rate of Fire.

A measure of the ability of a weapon to fire aimed rounds at a target. The direct fire program requires input data permitting the computer to generate the distribution of times, not only average times, that crews would need to fire the weapon in a firing engagement. Furthermore, care is necessary to ensure that the inputs correspond to rate of fire under combat conditions rather than test conditions generally tending to favor rapid fire.

2.30 First Round Firing Time.

Time elapsing between the beginning of the engagement and firing of the first round. Operations involved in firing of the first round include, as applicable, the following:

- a. Slewing of the weapon.
- b. Target recognition by the gunner.
- c. Ranging, which may be done with equipment, such as a rangefinder, or by visual estimation of the range to the target.
- d. Laying of the weapon.

Note that some of these operations can be carried out at the same time that others are. Loading of the first round may be included or excluded. In the latter case, the appropriate type of round is considered already loaded before recognition of the target.

2.31 Flight Time.

Time interval between the time a round begins to be propelled forward in the gun or launcher and the time it reaches the range of the target.

2.32 Subsequent Round Firing Time.

Time that elapses between firing of any round and firing of the next round against the same target. Subsequent round firing time involves,

as applicable, the following:

- a. Flight time of the previous round.
- b. Round loading.
- c. Relaying of the weapon, which may or may not reflect efforts to improve the aimpoint with reference to the aimpoint used for the previous round.

2.33 Fixed Time.

Portion of total firing time, for a first or a subsequent round, that is independent of environmental conditions, crew skill and level of training, or other causes of variation in firing time performance. This time is frequently associated with mechanical operations, such as automatic loading, for unguided rounds or with flight time of the previous round for missiles.

2.34 Variable Time.

Component of total first round or subsequent round firing time that needs to be represented by a distribution of times, rather than by a fixed time component. On any particular firing occasion, total firing time equals the sum of the applicable fixed time component and a particular time from the distribution describing the variable time component. Variable time is tied to human operations and generally tends not to equal zero, because there exist so many causes of variation that are not controllable, at least completely.

2.35 Median Time.

Median time can be defined as the particular time which is greater than half the times represented by the corresponding distribution and smaller than the remaining half. For the special case where a logarithmiconormal distribution is fitted to data consisting of N particular times, the median time is the N th root of the product of all times in the set of data considered. Alternatively, for this special case, the median time is the antilogarithm of the arithmetic mean of the N logarithms corresponding to the times constituting the basic data. Detailed studies made many years ago established that logarithmiconormal distributions seemed to correspond more closely than other known distributions to test data obtained for tank weapons of interest at the time. Distributions of this type are still considered useful to represent variable components of firing times for weapons of current concern.

2.36 Variability Factor.

Factor indicating to what extent the times represented by logarithmic normal distributions vary with reference to the applicable median times. A factor of about 0.5 (based on calculations with natural logarithms) has been found to apply consistently and is normally used, except when a specific reason for doing otherwise is identified. This factor is the standard deviation of the natural logarithms of time data for a particular set of conditions with reference to the natural logarithm of the median time.

2.37 Minimum Time.

Least time considered possible. Such a least time, if one other than zero is specified, can be made to override any unrealistically shorter times that may be implied by a particular time distribution used.

2.38 Kill Probability for Specified Engagement Time.

Probability that the target is killed when a specific engagement time, say T seconds, has elapsed since the beginning of the firing engagement. Specification of a kill criterion is also necessary. T is considered to equal 0 to 120 seconds for the program calculations. The kill probability associated with any specific time T is an aggregated result that accounts for kills that occur at any time up to T.

3. GENERAL FLOW OF PROGRAM LOGIC

3.1 Introduction.

This section provides a general indication of the principal steps involved in the simulation of firing engagements. Such an indication, which may suffice for many readers, is supplemented by the detailed explanations of the program logic that are contained in the appendixes.

3.2 Principal Program Steps.

The program instructions cause the computer to perform a sequence of steps. The flow can be complicated, principally when special purpose options are exercised. The principal steps for the basic program (exclusive of special purpose options) are as follows:

- a. Read input cards for the weapon/round/fire control type, target type, target exposure conditions, and range involved.
- b. Make all necessary adjustments to the card input data just read; for example, some data may require conversion from meters to inches.
- c. Skip any files on the vulnerability data tape that precede the kill probability and personnel casualty data needed.
- d. Read kill probability data from the vulnerability data tape for target orientation angles of 0 and 180, 30 and 210, 60 and 240, and 90 and 270 degrees. The two angles in each pair correspond to reverse directions. It is convenient to refer to the first angle as basic and to the second as the corresponding reverse angle. Steps e through j apply, in turn, to each pair of basic and reverse directions.
- e. Simulate the first firing engagement for the basic orientation angle. See 3.3 for details.
- f. Simulate the second firing engagement for the basic orientation angle, as for e.
- g. Likewise, simulate additional engagements until a total of 10,000 engagements for the basic orientation angle has been reached.
- h. Repeat steps e through g for the reverse orientation angle.
- i. Combine data from all 10,000 firing engagements for each angle of the matched pair of concern to determine the hit probability and kill probabilities corresponding to 1, 2, 3, etc., 14, 15 rounds, the average, or expected, numbers of rounds needed to hit or to kill the target, and the hit and kill probabilities corresponding to engagement times of 0, 2, 4, etc., 118, 120 seconds.
- j. Print as output the results obtained in step i.

3.3 Program Steps for Single Engagement at Particular Angle.

Simulation of a single firing engagement for a particular orientation angle begins with consideration of the first main round fired. Steps involved are as follows:

- a. Determine the number of seconds between the beginning of the engagement and the arrival of the first round at the target range.
- b. Determine if the first round flies reliably. If not, the target cannot be hit or killed and calculations for the next round begin immediately without any credit for sensing of the first round as a basis for adjustment of fire.
- c. If the first round has a reliable flight trajectory, determine the impact point in the plane of the target and whether or not the target is hit.
- d. If the first round misses the target, determine whether the round is sensed and begin calculations for the next round. The calculations for the next round eventually reflect whether or not adjustment of fire, to take advantage of information obtained by sensing, has been possible.
- e. If the round hits, determine whether reliable functioning of the fuze occurs. If not, the target cannot be killed and calculations for the next round begin without any further consideration of possible damaging effects on the target.
- f. If damaging effects are to be assessed, determine whether each of the various types of kill, i.e., M kill, F kill, M or F kill, and K kill, is inflicted on the target. Continue with the calculations for the second round whenever there is at least one kill criterion according to which the target has not been killed by the first round. If the target has been killed according to all criteria, proceed to simulation of the second firing engagement.

Unless the engagement is over, simulate firing of the second main round as follows:

- g. Determine the number of seconds between firing of the first round and firing of the second round. Add this number to the time of arrival of the first round at the target range to obtain the time between the start of the engagement and the arrival of the second round at the target range.

- h. Determine if the second round flies reliably. If not, proceed as for b above, i.e., begin calculations for the next round.

i. If the second round has a reliable flight trajectory, determine the impact point in the plane of the target and whether or not the target is hit, as for c. The second round is assumed fired with the same aimpoint as for the first round if the latter is not sensed, or with a new aimpoint based on sensing information.

j. If the second round misses the target, determine whether the round is sensed and begin calculations for the next round, as for d.

k. If the round hits, determine whether damaging effects are not to be assessed because of unreliable functioning of the fuze. If the fuze does not function reliably, begin calculations for the next round, as for e.

l. If damaging effects on the target are to be assessed, determine whether each of the various types of kill still being considered is inflicted on the target. Continue with the calculations for the third round whenever there is at least one kill criterion according to which the target has not yet been killed, or proceed to simulation of the second firing engagement.

If the engagement is not yet over after two rounds, simulate firing of the third round and succeeding rounds, as necessary, but not beyond the fifteenth round. Steps g through l also apply to each round following the second round. Times at which rounds arrive at the target range are ignored whenever these times are beyond 2 minutes from the start of the engagement.

3.4 Special Options.

Listing of the various special options available is not attempted here. Two examples, selected somewhat arbitrarily, are as follows:

a. A vulnerability data tape or disc is not absolutely required. It may be possible to substitute a set of input cards containing detailed target shape information identical to that on the tape or disc. Target shape data are sufficient if hit probabilities, but not kill probabilities, need to be computed. Although it would be possible to use input cards, rather than a tape or disc, for detailed vulnerability data also, this is impractical.

b. Calculations can be made for simplified engagements each involving the firing of only one round. In particular, single round hit probabilities and kill probabilities can be obtained for a moving target or a moving firing tank. However, this does not imply that the program can actually simulate in detail the movement of the target or firing tank.

4. INPUT DATA

4.1 Introduction.

The direct fire program can make calculations for several combinations of conditions considered in sequence. However, it is sufficient for this report to emphasize a single basic cycle definable as all the calculations for:

- a. A specified firing weapon, round type, and fire control system.
- b. A particular target.
- c. One target exposure condition, i.e., the target is fully exposed or in defilade.
- d. One range.
- e. One of the orientation angles 0, 30, 60, or 90 degrees and the corresponding angle for the reverse direction. Matched pairs of angles are 0 and 180, 30 and 210, 60 and 240, and 90 and 270 degrees.

The input data required for a single basic cycle consist of both a set of cards, and normally, a tape or disc file. The cards contain control quantities as well as information related to aimpoint, reliability, delivery accuracy, and rate of fire. The tape or disc provides target vulnerability data.

This report documents the input data used for a sample computer run and the corresponding output results. For this sample run, it was more important to illustrate input and output quantities in detail than to consider weapon, target, and other combat engagement conditions of real concern. The inputs developed for the purpose just stated are identified in this section. They are suitable for illustrating input requirements and formats in detail and, while possibly similar to classified data of actual interest, are not applicable to a specific set of engagement conditions.

4.2 Card Inputs.

Contents of the input cards required to run the direct fire program are listed and briefly described in Table 4.1. The role of some input quantities should be evident from the table. Several other quantities, however, can be fully understood only in connection with detailed explanations subsequently provided. Cards numbered 1 through 5 contain controls needed for each computer run and applicable to each range regardless of how many ranges are grouped for the run. Integer controls are on the first three of these cards, and real quantities on the last two cards. Cards numbered R1 through R8 are needed for each range. Except for the integer controls

TABLE 4.1 CONTENTS OF PROGRAM INPUT CARDS

CARD	COLUMNS	SYMBOL	FORMAT	EXAMPLE	UNITS	EXPLANATION OF SYMBOL
1	1-10	IDCODE	10A1	R159851340		CODE CONSISTING OF RUN IDENTIFIER (R15 IN EXAMPLE), ROUND IDENTIFIER(985), AND TARGET IDENTIFIER(1340)
2	1- 5	NRSKP	I5	3		NUMBER OF VULNERABILITY DATA FILES TO BE SKIPPED ON TAPE OR DISC TO REACH FIRST FILE FOR ROUND/TARGET COMBINATION INVOLVED IN RUN
	6-10	NCASES	I5	10		NUMBER OF RANGES GROUPED TOGETHER FOR COMPUTER RUN
	11-15 16-20	NRFRST NTGT	I5 I5	250 2	METERS	FIRST RANGE INVOLVED IN CALCULATIONS TARGET TYPE CODE ASSOCIATED WITH FORMAT USED TO ENTER VULNERABILITY DATA ON TAPE OR DISC
	21-25	NRDTYP	I5	0		ROUND TYPE CODE SET TO 0 IF VULNERABILITY DATA DO NOT VARY WITH RANGE, OR 1 OTHERWISE
	26-30	NRD1	I5	0		CONTROL SET TO 1 IF ONLY ONE ROUND IS OF INTEREST FOR EACH ENGAGEMENT, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
	31-35	NRDS	I5	15		MAXIMUM NUMBER OF ROUNDS TO BE FIRED PER ENGAGEMENT
	36-40	NADJST	I5	0		CONTROL SET TO 1, 2, 3, 4, OR 5 IF ASSOCIATED ADJUSTMENT PROCEDURE IS TO BE USED AFTER MISSING ROUND, OR 0 FOR BASIC PROCEDURE INVOLVING ADJUSTMENT BASED ON SENSING WHEN POSSIBLE AND RELAYING ON PREVIOUS AIMPOINT OTHERWISE
	41-45	NRFBS	I5	1		CONTROL SET TO 1 IF AIMPOINT IS APPROXIMATE CENTER OF MASS OF TARGET (AS WHEN RANGING IS DONE WITH RANGEFINDER), OR 2 IF VERTICAL COORDINATE OF AIMPOINT CORRESPONDS TO BASE OF TARGET (AS WHEN BATTLESIGHT IS USED)
	46-50	NDROP	I5	0		CONTROL SET TO 1, 2, 3, 4, 5, OR 6 WHEN VERTICAL CHANGE IS INVOLVED IN ADJUSTMENT PROCEDURE AFTER MISSING ROUND THAT IS NOT SENSED, OR 0 OTHERWISE

TABLE 4.1 CONTENTS OF PROGRAM INPUT CARDS (CONTINUED)

51-55	NHIT	I5	0	CONTROL SET TO ANY NUMBER NOT 0 (1 PREFERRED) IF AIMPOINT IS TO BE ADJUSTED TOWARD TARGET CENTER AFTER TARGET IS HIT, OR 0 OTHERWISE CONTROL SET TO 1 IF HIT PROBABILITIES ARE ONLY DESIRED OUTPUT, OR 0 OTHERWISE CONTROL SET TO 1 IF REHIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND HIT IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
56-60	NPRHIT	I5	0	CONTROL SET TO 1 IF REHIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND HIT THAT DOES NOT CAUSE K KILL IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
61-65	NDTRM1	I5	0	CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND MISS IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
66-70	NDTRM2	I5	0	CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND MISS IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
3 1- 5	NDTRM3	I5	0	CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND MISS IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
6-10	NDTRM4	I5	0	CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER SENSED MISS ON FIRST ROUND IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
11-15	NDTRM5	I5	0	CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER UNSENSED MISS ON FIRST ROUND IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
16-20	NHTKLL	I5	0	CONTROL SET TO 0 IF DETERMINISTIC CALCULATIONS OF CERTAIN HIT AND KILL PROBABILITIES ARE NOT TO BE MADE WITH DATA FROM INPUT CARDS, 9 IF SUCH CALCULATIONS ARE TO BE MADE AND RESULTS TO CONSTITUTE ONLY OUTPUT, OR ANY NUMBER NOT 0 OR 9 (1 PREFERRED) IF SUCH CALCULATIONS ARE TO BE MADE IN ADDITION TO SIMULATION OF MONTE CARLO ENGAGEMENTS

TABLE 4.1 CONTENTS OF PROGRAM INPUT CARDS (CONTINUED)

21-25	NTCRD1	I5	0	CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 0 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE		
26-30	NTCRD2	I5	0	CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 30 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE		
31-35	NTCRD3	I5	0	CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 60 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE		
36-40	NTCRD4	I5	0	CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 90 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE		
4	1-10	PASSN	F10.4	6.0000	MEN	NUMBER OF TARGET PASSENGER PERSONNEL, EXCLUDING CREW
11-20	WCELL	F10.4		4.0000	INCHES OR MILLIMETERS	DIMENSION OF EACH TARGET CELL, WHICH CAN BE ONLY 4.0000 FOR 4 INCHES OR 100.0000 FOR 100 MILLIMETERS
21-30	XC	F10.4		0.0000	LIKE WCELL	HORIZONTAL COORDINATE OF POINT CHOSEN AS APPROXIMATE CENTER OF MASS OF TARGET
31-40	YC	F10.4		-28.0000	LIKE WCELL	VERTICAL COORDINATE OF POINT CHOSEN AS APPROXIMATE CENTER OF MASS OF TARGET
41-50	YBASE	F10.4		-70.0000	LIKE WCELL	MINIMUM VERTICAL COORDINATE OF UNSHIELDED PORTION OF TARGET
51-60	YTOP	F10.4		9999.9999	LIKE WCELL	VERTICAL COORDINATE OF POINT CHOSEN AS APPROXIMATE TOP OF TARGET. USUALLY UNNEEDED AND SET TO 9999.9999. ANY OTHER SETTING INDICATES ADJUSTMENT PROCEDURE ASSOCIATED WITH NDROP EQUALLING 1 APPLIES AFTER MISSING ROUND.
61-70	RELT	F10.4		0.9900		PROBABILITY OF RELIABLE PROJECTILE FLIGHT FOR EACH ROUND FIRED
5	1-10	RELF	F10.4	0.9280		PROBABILITY OF RELIABLE FUZE FUNCTIONING FOR EACH ROUND FIRED

TABLE 4.1 CONTENTS OF PROGRAM INPUT CARDS (CONTINUED)

R1	1-5 6-10	IRANGE INTPL	I5 I5	250 0	METERS	TARGET RANGE RANGE INTERPOLATION CONTROL SET TO 1 IF NRDTP EQUALS 1 AND IRANGE IS NOT MULTIPLE OF 500 METERS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE CONTROL SET TO 0 FOR METERS OR 1 FOR MILS TO INDICATE UNITS CHOSEN FOR VARIOUS DATA ON CARDS R3 THROUGH R8
R2	11-15	IMILS	I5	0		
	1-10 11-20 21-30 31-40 41-50	FLT TF1 TFS XM1 XM2	F10.4 F10.4 F10.4 F10.4 F10.4	1.7100 0.0000 0.0000 19.8000 15.6000	SECONDS SECONDS SECONDS SECONDS SECONDS	PROJECTILE TIME OF FLIGHT FIXED FIRING TIME FOR FIRST ROUND FIXED FIRING TIME FOR EACH SUBSEQUENT ROUND MEDIAN VARIABLE FIRING TIME FOR FIRST ROUND MEDIAN VARIABLE FIRING TIME FOR EACH SUBSEQUENT ROUND
	51-60 61-70	AMT1 AMT2	F10.4 F10.4	0.0000 0.0000	SECONDS SECONDS	MINIMUM FIRING TIME FOR FIRST ROUND MINIMUM FIRING TIME FOR EACH SUBSEQUENT ROUND
R3	1-10 11-20	STD1 STD2	F10.4 F10.4	0.0000 0.0000		TIME VARIABILITY FACTOR FOR FIRST ROUND TIME VARIABILITY FACTOR FOR EACH SUBSEQUENT ROUND
	21-30	XB	F10.4	0.0357	METERS OR MILS	HORIZONTAL FIXED BIAS FOR FIRST ROUND
	31-40	YB	F10.4	1.0161	METERS OR MILS	VERTICAL FIXED BIAS FOR FIRST ROUND
	41-50	SIGXB	F10.4	2.7038	METERS OR MILS	HORIZONTAL VARIABLE BIAS STANDARD DEVIATION FOR FIRST ROUND
	51-60	SIGYB	F10.4	5.5923	METERS OR MILS	VERTICAL VARIABLE BIAS STANDARD DEVIATION FOR FIRST ROUND
	61-70	SIGXL	F10.4	0.2277	METERS OR MILS	HORIZONTAL LAY ERROR STANDARD DEVIATION FOR FIRST ROUND
R4	1-10	SIGYL	F10.4	0.2277	METERS OR MILS	VERTICAL LAY ERROR STANDARD DEVIATION FOR FIRST ROUND
	11-20	SIGXR	F10.4	0.6136	METERS OR MILS	HORIZONTAL ROUND-TO-ROUND ERROR STANDARD DEVIATION
	21-30	SIGYR	F10.4	0.6872	METERS OR MILS	VERTICAL ROUND-TO-ROUND ERROR STANDARD DEVIATION
	31-40	PROBS	F10.4	0.7800		PROBABILITY OF GUNNER AND/OR COMMANDER SENSING MISSING ROUND
	41-50	SIGXS	F10.4	1.4635	METERS OR MILS	HORIZONTAL SENSING ERROR STANDARD DEVIATION

TABLE 4.1 CONTENTS OF PROGRAM INPUT CARDS (CONTINUED)

51-60	SIGYS	F10.4	1.4635	METERS OR MILS	VERTICAL SENSING ERROR STANDARD DEVIATION
61-70	PGH	F10.4			PROBABILITY OF GUNNER SENSING ROUND THAT MISSES HIGH
R5					
1-10	PGS	F10.4			PROBABILITY OF GUNNER SENSING ROUND THAT MISSES SHORT
11-20	PGCH	F10.4			PROBABILITY OF GUNNER AND/OR COMMANDER SENSING ROUND THAT MISSES HIGH
21-30	PGCS	F10.4			PROBABILITY OF GUNNER AND/OR COMMANDER SENSING ROUND THAT MISSES SHORT
31-40	SGHX	F10.4		METERS OR MILS	HORIZONTAL SENSING ERROR STANDARD DEVIATION FOR GUNNER SENSING OF ROUND THAT MISSES HIGH
41-50	SGHY	F10.4		METERS OR MILS	VERTICAL SENSING ERROR STANDARD DEVIATION FOR GUNNER SENSING OF ROUND THAT MISSES HIGH
51-60	SGSX	F10.4		METERS OR MILS	HORIZONTAL SENSING ERROR STANDARD DEVIATION FOR GUNNER SENSING OF ROUND THAT MISSES SHORT
61-70	SGSY	F10.4		METERS OR MILS	VERTICAL SENSING ERROR STANDARD DEVIATION FOR GUNNER SENSING OF ROUND THAT MISSES SHORT
R6					
1-10	CDRX	F10.4		METERS OR MILS	HORIZONTAL ADD-ON SENSING ERROR STANDARD DEVIATION TO BE COMBINED WITH SGHX OR SGSX FOR COMMANDER SENSING OF MISSING ROUND
11-20	CDRY	F10.4		METERS OR MILS	VERTICAL ADD-ON SENSING ERROR STANDARD DEVIATION TO BE COMBINED WITH SGHY OR SGSY FOR COMMANDER SENSING OF MISSING ROUND
21-30	HSX	F10.4		METERS OR MILS	HORIZONTAL ERROR STANDARD DEVIATION FOR GUNNER ADJUSTMENT OF HITTING ROUND TOWARD TARGET CENTER
31-40	HSY	F10.4		METERS OR MILS	VERTICAL ERROR STANDARD DEVIATION FOR GUNNER ADJUSTMENT OF HITTING ROUND TOWARD TARGET CENTER
41-50	XBH	F10.4		METERS OR MILS	HORIZONTAL FIXED BIAS FOR ROUND FOLLOWING HITTING ROUND
51-60	YBH	F10.4		METERS OR MILS	VERTICAL FIXED BIAS FOR ROUND FOLLOWING HITTING ROUND
61-70	SIGX8H	F10.4		METERS OR MILS	HORIZONTAL VARIABLE BIAS STANDARD DEVIATION FOR ROUND FOLLOWING HITTING ROUND

TABLE 4.1 CONTENTS OF PROGRAM INPUT CARDS (CONTINUED)

R7	1-10	SIGYBH	F10.4	METERS OR MILS	VERTICAL VARIABLE BIAS STANDARD DEVIATION FOR ROUND FOLLOWING HITTING ROUND
	11-20	XBL	F10.4	METERS OR MILS	HORIZONTAL FIXED BIAS FOR ROUND FOLLOWING MISSING ROUND THAT IS NOT SENSED
	21-30	YBL	F10.4	METERS OR MILS	VERTICAL FIXED BIAS FOR ROUND FOLLOWING MISSING ROUND THAT IS NOT SENSED
	31-40	SIGXBL	F10.4	METERS OR MILS	HORIZONTAL VARIABLE BIAS STANDARD DEVIATION FOR ROUND FOLLOWING MISSING ROUND THAT IS NOT SENSED
	41-50	SIGYBL	F10.4	METERS OR MILS	VERTICAL VARIABLE BIAS STANDARD DEVIATION FOR ROUND FOLLOWING MISSING ROUND THAT IS NOT SENSED
	51-60	XBS	F10.4	METERS OR MILS	HORIZONTAL FIXED BIAS FOR ROUND FOLLOWING MISSING ROUND THAT IS SENSED
	61-70	YBS	F10.4	METERS OR MILS	VERTICAL FIXED BIAS FOR ROUND FOLLOWING MISSING ROUND THAT IS SENSED
R8	1-10	SIGXBS	F10.4	METERS OR MILS	HORIZONTAL VARIABLE BIAS STANDARD DEVIATION FOR ROUND FOLLOWING MISSING ROUND THAT IS SENSED
	11-20	SIGYBS	F10.4	METERS OR MILS	VERTICAL VARIABLE BIAS STANDARD DEVIATION FOR ROUND FOLLOWING MISSING ROUND THAT IS SENSED

on the R1 card, all input data on these cards are real. The EXAMPLE column of Table 4.1 contains the data used for the run that yielded the sample outputs presented in section 5. Since IMILS is set to 0, meters are the unit associated with cards R3 through R6. Blanks on cards R4 through R8 correspond to input quantities associated with special options that were not exercised in the sample run.

The manner in which input data are actually arranged on cards is illustrated in Table 4.2. This table contains the same inputs as the previous one. The first portion of the table shows how the basic control cards (identifiable by R15 A, B, C, D, E entered in the last 8 columns) are followed by the 8 cards corresponding to 250 meters (identifiable by R15 2501, 2, 3, 4, 5, 6, 7, 8 in these same columns). The 250-meter cards would be followed if necessary by similar groups of 8 cards for other ranges. The remainder of the table repeats the card images, with headings added to facilitate relating each quantity to the explanatory information in Table 4.1.

4.3 Tape or Disc Inputs.

Vulnerability data constituting needed tape or disc input information are generated by the Vulnerability Division of the Ballistic Research Laboratory (BRL). These data are extensive in scope and consist of kill probabilities for a large number of specific impact points on the target. These impact points are selected from the grid squares obtained by dividing the target as shown in Figure 4.1. These squares, usually called cells, are either 4 inches (101.6mm) or 100mm on each side. One impact point is chosen from each cell and data developed for that point are then considered representative of the effects of a hit anywhere on the cell. Table 4.3 illustrates a portion of the data. The associated conditions are not identifiable, since fictitious projectile, target, and range headings appear in the table. The coordinates X and Y are those of the center of each cell and refer to a suitably selected origin, e.g., at the turret center line for some tank targets or at the base of the target. Each line of data includes probabilities of M kill, F kill, M or F kill (M/F in the table), and K kill, as well as expected casualties when applicable, given a hit on the cell of interest for both a basic orientation angle and the corresponding reverse angle. Note that the reverse angle corresponding here to 30 degrees is 150 degrees. This reflects the assumption, established by BRL, that a single set of vulnerability data can reasonably be used for symmetrically related directions, like 150 and 210 degrees, that represent attack of a target from the right in one instance and from the left in the other.

The vulnerability data used for the sample computer run differ from those partly shown in Table 4.3, but need not be identified further.

The points labelled A, B, C, and D in Figure 4.1 are the corners of a rectangle just large enough to enclose the target representation. Such a rectangle is referred to in some of the explanations in Appendix A.

TABLE 4.2 SAMPLE INPUT CARD DATA (CONTINUED)

CARD R15	E	REL F				R15	E
0.9280							
CARD R15	2501	IRANGE,INTPL,IMILS				R15	2501
250	0						
CARD R15	2502	FLT,TF1,IFS,XM1,XM2,AMT1,AMT2				R15	2502
1.7100	0.0000	0.0000 19.8000 15.6000	0.0000	0.0000			
CARD R15	2503	STD1,STD2,XB,YB,SIGXB,SIGYB,SIGXL				R15	2503
0.0000	0.0000	0.0357 1.0161 2.7038	5.5923	0.2277			
CARD R15	2504	SIGYL,SIGXR,SIGYR,PROBS,SIGXS,SIGYS,PGH				R15	2504
0.2277	0.6136	0.6872 0.7800 1.4635	1.4635				
CARD R15	2505	PGS,PGCH,PGCS,SGHX,SGHY,SGSX,SGSY				R15	2505
CARD R15	2506	CDRX,CDRY,HSX,HSY,XBH,YBH,SIGXBH				R15	2506
CARD R15	2507	SIGYBH,XBL,YBL,SIGXBL,SIGYBL,XBS,YBS				R15	2507
CARD R15	2508	SIGXBS,SIGYBS				R15	2508

Note: A, B, C, and D are corners of rectangle enclosing target.

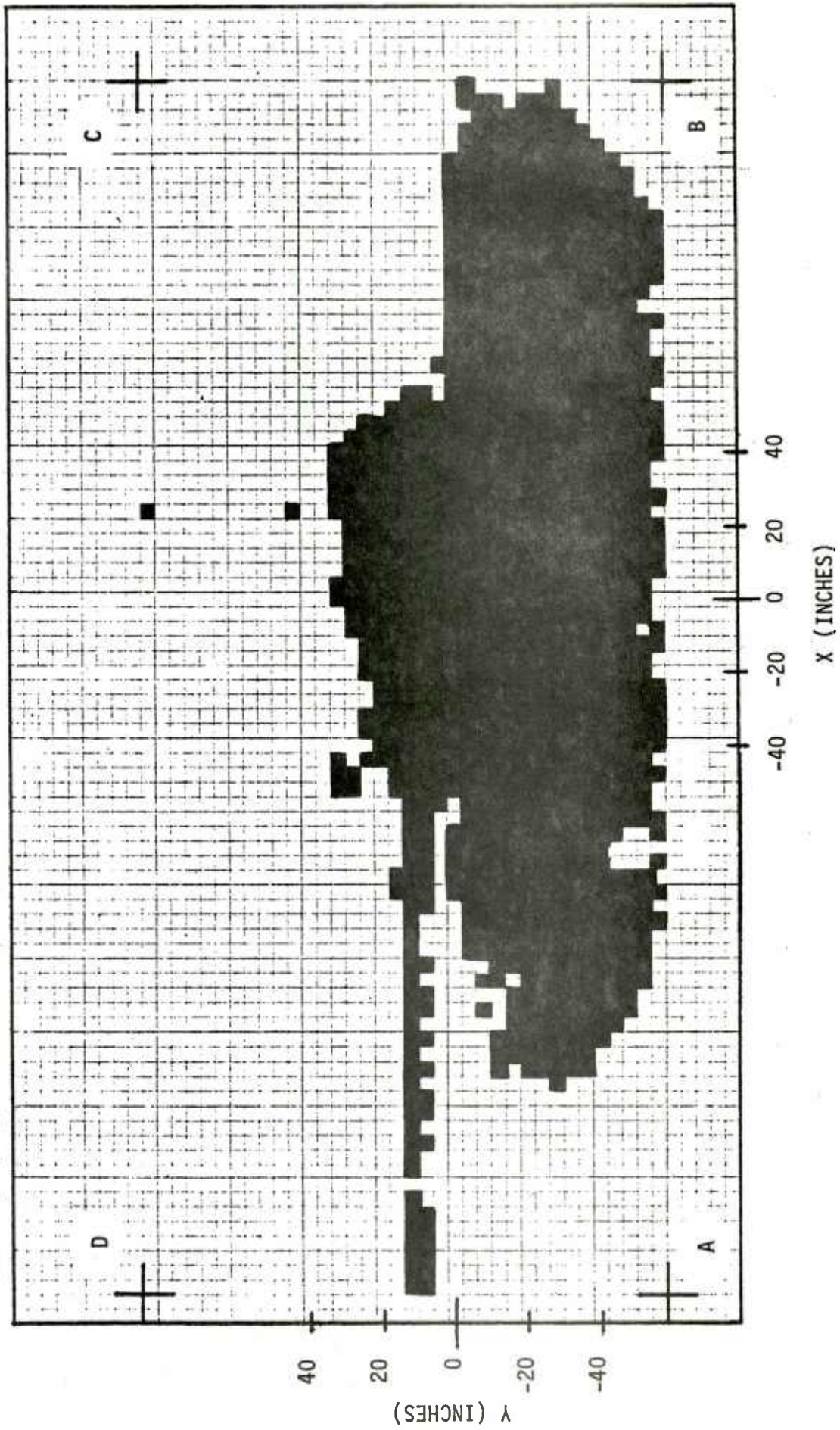


FIGURE 4.1 MEDIUM TANK TARGET AT ORIENTATION OF 60 DEGREES

4.4 Requirements for Special Options.

A special option, already mentioned in 3.4, permits using input cards with target shape information instead of the vulnerability data tape or disc normally required for a run. Card requirements associated with this option are illustrated in Table 4.4. Numbers are grouped by threes. For example, 76, -28, -8 mean that the target includes an unbroken string of cells whose centers have coordinates $(-28,76)$, $(-24,76)$, $(-20,76)$, $(-16,76)$, $(-12,76)$, and $(-8,76)$, while 88, -24, -24 simply identify an isolated cell the coordinates of whose center are $(-24,88)$. The total target can thus be specified as a combination of horizontal strips of cells and, normally, some isolated cells toward the edges. The target shape card option has been restricted to only four orientations, namely, 0, 30, 60, and 90 degrees, identified in columns 77 and 78 on the cards. The sample run documented in this report did not involve target shape data cards.

The direct fire program has been designed to permit certain calculations for a moving target or a moving firing tank. Single round hit probabilities and kill probabilities are obtainable for sets of up to 18 conditions. Input card requirements are then as explained in connection with Table 4.1, except for two differences. First, on the R1 card for only the first range involved in the run, INTPL does not have the previously explained meaning but should be set to 987. The second difference is that each R3 card is replaced by a set of 18 such cards. It is assumed that, from other sources, biases and overall standard deviations including contributions of lay and round-to-round errors are known. Thus, these overall standard deviations can be entered in SIGXB and SIGYB, redefined accordingly; redefinition of the biases XB, YB is not necessary. Tape or disc input requirements are not affected. Sections of the computer program that specifically apply to moving target or moving firing tank calculations were not exercised in the sample run made for this report.

TABLE 4.4 SAMPLE CARDS WITH TARGET SHAPE DATA

88-	24-	24	88	8	8	84-	24-	24	84-	8-	8	1340 0 1
84	8	8	84	24	24	80-	24-	20	80-	8-	8	1340 0 2
80	8	8	80	24	24	76-	28-	8	76	8	12	1340 0 3
E T C												
-	20-	36-	28-	20	28	36	9999	9999	9999			1340 015
88-	4-	88	20	24	24	84-	4-	4	84	8	8	134030 1
84	24	36	80	0	20	80	28	44	80	52	52	134030 2
76	0	48	76	64	64	72	4	64	68	4	60	134030 3
E T C												
-	20	36	48	9999	9999	9999						13403014
92	24	24	88	12	16	88	28	28	84	20	36	134060 1
E T C												

COLUMNS

1	2	3	4	5	6	7	8
123456789012345678901234567890123456789012345678901234567890							
CARD 1340 0 1	NCTRY(1,1),	NCTRY(2,1),	NCTRY(3,1),	NCTRY(4,1),	NCTRX(1,1),	NCTRX(2,1),	NCTRX(3,1),
	NCTRY(1,1),	NCTRY(2,1),	NCTRY(3,1),	NCTRY(4,1),	NCTRX(1,1),	NCTRX(2,1),	NCTRX(3,1),
	NCTRY(1,1),	NCTRY(2,1),	NCTRY(3,1),	NCTRY(4,1),	NCTRX(1,1),	NCTRX(2,1),	NCTRX(3,1),
88- 24- 24 88 8	8	8	84- 24- 24 84-	8	8	1340 0 1	
CARD 1340 0 2	NCTRY(5,1),	NCTRY(6,1),	NCTRY(7,1),	NCTRY(8,1),	NCTRX(5,1),	NCTRX(6,1),	NCTRX(7,1),
	NCTRY(5,1),	NCTRY(6,1),	NCTRY(7,1),	NCTRY(8,1),	NCTRX(5,1),	NCTRX(6,1),	NCTRX(7,1),
	NCTRY(5,1),	NCTRY(6,1),	NCTRY(7,1),	NCTRY(8,1),	NCTRX(5,1),	NCTRX(6,1),	NCTRX(7,1),
84 8 8 84 24 24	80- 24- 20 80-	8	8	1340 0 2			
CARD 1340 0 3	NCTRY(9,1),	NCTRY(10,1),	NCTRY(11,1),	NCTRY(12,1),	NCTRX(9,1),	NCTRX(10,1),	NCTRX(11,1),
	NCTRY(9,1),	NCTRY(10,1),	NCTRY(11,1),	NCTRY(12,1),	NCTRX(9,1),	NCTRX(10,1),	NCTRX(11,1),
	NCTRY(9,1),	NCTRY(10,1),	NCTRY(11,1),	NCTRY(12,1),	NCTRX(9,1),	NCTRX(10,1),	NCTRX(11,1),

TABLE 4.4 SAMPLE CARDS WITH TARGET SHAPE DATA (CONTINUED)

80	8	8	80	24	24	76-	28-	8	76	8	12	1340 0 3
						NCTRY(11,1),	NCTRXL(11,1),		NCTRXR(11,1),			
						NCTRY(12,1),	NCTRXL(12,1),		NCTRXR(12,1),			

E T C

CARD	1340	015										
						NCTRY(57,1),	NCTRXL(57,1),		NCTRXR(57,1),			
						NCTRY(58,1),	NCTRXL(58,1),		NCTRXR(58,1),			
						NCTRY(59,1),	NCTRXL(59,1),		NCTRXR(59,1),			
						NCTRY(60,1),	NCTRXL(60,1),		NCTRXR(60,1),			

20-	36-	28-	20	28	36	9999	9999	9999		1340 015
-----	-----	-----	----	----	----	------	------	------	--	----------

CARD	134030	1										
						NCTRY(1,2),	NCTRXL(1,2),		NCTRXR(1,2),			
						NCTRY(2,2),	NCTRXL(2,2),		NCTRXR(2,2),			
						NCTRY(3,2),	NCTRXL(3,2),		NCTRXR(3,2),			
						NCTRY(4,2),	NCTRXL(4,2),		NCTRXR(4,2),			
88-	4-	4	88	20	24	84-	4-	4	84	8		134030 1

CARD	134030	2										
						NCTRY(5,2),	NCTRXL(5,2),		NCTRXR(5,2),			
						NCTRY(6,2),	NCTRXL(6,2),		NCTRXR(6,2),			
						NCTRY(7,2),	NCTRXL(7,2),		NCTRXR(7,2),			
						NCTRY(8,2),	NCTRXL(8,2),		NCTRXR(8,2),			
84	24	36	80	20	20	80	28	44	80	52		134030 2

CARD	134030	3										
						NCTRY(9,2),	NCTRXL(9,2),		NCTRXR(9,2),			
						NCTRY(10,2),	NCTRXL(10,2),		NCTRXR(10,2),			
						NCTRY(11,2),	NCTRXL(11,2),		NCTRXR(11,2),			
						NCTRY(12,2),	NCTRXL(12,2),		NCTRXR(12,2),			
76	0	48	76	6	64	72	4	64	68	4	60	134030 3

E T C

TABLE 4.4 SAMPLE CARDS WITH TARGET SHAPE DATA (CONTINUED)

CARD	13403014	NCTRY(53,2),	NCTRXL(53,2),	NCTRXR(53,2),	
		NCTRY(54,2),	NCTRXL(54,2),	NCTRXR(54,2),	
		NCTRY(55,2),	NCTRXL(55,2),	NCTRXR(55,2),	
		NCTRY(56,2),	NCTRXL(56,2),	NCTRXR(56,2),	
20	36	48	9999	9999	13403014
CARD	134060	1	NCTRY(1,3),	NCTRXL(1,3),	NCTRXR(1,3),
			NCTRY(2,3),	NCTRXL(2,3),	NCTRXR(2,3),
			NCTRY(3,3),	NCTRXL(3,3),	NCTRXR(3,3),
			NCTRY(4,3),	NCTRXL(4,3),	NCTRXR(4,3),
92	24	24	88	12	16
				88	28
				28	84
				20	36
					134060
					1

E T C

5. OUTPUT DATA

5.1 Introduction.

Output results provided by the direct fire program consist primarily of cumulative hit probabilities and kill probabilities for up to 15 rounds, average numbers of rounds expected to be needed to hit or kill targets, and cumulative hit probabilities and kill probabilities versus engagement time for up to 2 minutes. In addition, cumulative passenger casualties expected for up to 15 rounds are included for personnel carrier targets. Information useful for verifying the input data used also constitutes a part of the printed output.

5.2 Outputs of Sample Computer Run.

The input quantities identified in Table 4.1 (and Table 4.2) and data from a vulnerability data tape were used to make a sample run. Table 5.1 presents selected results of this run.

All data from the input cards used for a run are rewritten exactly as they appear on the cards. The same data are generally repeated with corresponding program symbols and a brief indication of what the symbols mean. Exceptionally, quantities associated with the program symbols may not be strictly identical to the related card quantities. For example, the dimension of target cells may be in millimeters originally and converted to inches.

Identifying conditions associated with input information provided by the vulnerability data tape or disc are printed, but the actual vulnerability data are not.

The number of samples is not calculated but has been fixed in the program itself at 10,000.

Angles 1 and 2 designate target orientation directions of 0 and 180 degrees respectively. Data already identified as the primary output results of a run are printed for each such related pair of target orientations (angles 1 and 2, 3 and 4, etc.).

Cumulative hit probabilities and kill probabilities, as well as personnel casualties when applicable, for up to 15 rounds are arranged in twelve columns of 15 quantities each. Reading horizontally, one sees two sets of five columns followed by two columns. The first five columns correspond to the first angle (0 degrees for the first pair of angles) and are, from left to right, cumulative probabilities of achieving an M kill, an F kill, an M or F kill, a K kill, or a hit on the target. The next five columns contain this same information, similarly arranged, for the second angle (180 degrees for the first pair). The last two columns, printed only when they apply, are cumulative passenger casualties for the two angles (0 and 180 degrees) respectively.

TABLE 5.1 SAMPLE OUTPUT DATA

R159851340

3	10	250	2	0	0	15	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0						

NRSKP	VULN. TAPE FILES TO SKIP	3
NCASES	NO. OF CASES	10
NRFRST	FIRST RANGE FOR VULN. DATA	250
NTGT	VULN. TAPE FORMAT	2
NRDTYP	VULN. DATA DEP. ON RANGE	0
NRD1	SINGLE ROUND ENGAGEMENT	0
NRDS	MAX. NO. OF RDS.	15
NADJST	SP. PROC. FOR MISS. RD.	0
NRFBS	RANGEFINDER OR BATTLESIGHT	1
NRDOP	STANDARD DROP ADJUSTMENT	0
NHIT	ADJ. HIT	0
NPRHIT	HIT PROB. OUTPUT ONLY	0
NDTRM1	DETERMINISTIC2 HIT1	0
NDTRM2	DET2 NO K KILL HIT1	0
NDTRM3	DET2 MISS1	0
NDTRM4	DET2 OBSERVED MISS1	0
NDTRM5	DET2 UNOBSERVED MISS1	0
NHTKLL	HIT AND KILL PROB. INPUT	0
NTCRD1	CARDS FOR TARGET1	0
NTCRD2	CARDS FOR TARGET2	0
NTCRD3	CARDS FOR TARGET3	0
NTCRD4	CARDS FOR TARGET4	0

6.0000	4.0000	0.0000	-28.0000	-70.0000	9999.9999	.9900
.9280						

			HOR.	VERT.
PASSN	TGT. PERS. EXCL. CREW	6.0000		
W,W	CELL DIM. IN INCHES		4.0000	4.0000
XC,YC	TGT. CTR. COORD. INS.		0.0000	-28.0000
YBASE	TGT. BOT. COORD. INS.			-70.0000
YTOP	TOP APPR. COORD. INS.			9999.9999
RELT	PROB. OF REL. FLIGHT	.9900		
RELF	PROB. OF REL. FUZE	.9280		

TABLE 5.1 SAMPLE OUTPUT DATA (CONTINUED)

250 0 0

1.7100	0.0000	0.0000	19.8000	15.6000	0.0000	0.0000
0.0000	0.0000	.0357	1.0161	2.7038	5.5923	.2277
.2277	.6136	.6872	.7800	1.4635	1.4635	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000					

TIME DATA (SECONDS)
1ST RD. SUBS. RDS.

FLT	TIME OF FLIGHT	1.7100		
TF1,TFS	FIXED TIME		0.0000	0.0000
XM1, XM2	MEDIAN VARIABLE TIME		19.8000	15.6000
AMT1, AMT2	MINIMUM TIME		0.0000	0.0000
STD1, STD2	VARIABILITY FACTOR		0.0000	0.0000

ACCURACY DATA (METERS)
HOR. VERT.

XB,YB	FIXED BIAS		.0357	1.0161
SIGXB,SIGYB	VAR. BIAS STD. DEV.		2.7038	5.5923
SIGXL,SIGYL	LAY ERROR STD. DEV.		.2277	.2277
SIGXR,SIGYR	RD.-TD-RD. STD. DEV.		.6136	.6872
PROBS	PROB. SENS. MISS. RD.	.7800		
SIGXS,SIGYS	SENS. ERROR STD. DEV.		1.4635	1.4635

PROJECTILE 985 VS. VEHICLE 1340

TASK SHEET IDENTIFICATION	R15
PROJECTILE CODE	985
TARGET CODE	1340
RANGE IN METERS	250

087

0 DEG ELEV, 0 DEG AZIM					0 DEG ELEV, 180 DEG AZIM						
X	Y	M	F	M/F	K	EC	M	F	M/F	K	EC

0 DEG ELEV, 30 DEG AZIM					0 DEG ELEV, 150 DEG AZIM						
X	Y	M	F	M/F	K	EC	M	F	M/F	K	EC

0 DEG ELEV, 60 DEG AZIM					0 DEG ELEV, 120 DEG AZIM						
X	Y	M	F	M/F	K	EC	M	F	M/F	K	EC

TABLE 5.1 SAMPLE OUTPUT DATA (CONTINUED)

0 DEG ELEV, 90 DEG AZIM							0 DEG ELEV, 270 DEG AZIM				
X	Y	M	F	M/F	K	EC	M	F	M/F	K	EC
NUMBER OF SAMPLES = 10000											
ANGLES = 1 2											
NRDS	PROB. (EXP. CAS.)										
1	.0310000	.0300000	.0310000	.0212000	.0352000						
2	.1578000	.1529000	.1585000	.1060000	.1762000						
3	.2747000	.2677000	.2754000	.1969000	.3043000						
4	.3877000	.3763000	.3882000	.2884000	.4238000						
5	.4793000	.4681000	.4796000	.3695000	.5178000						
6	.5568000	.5450000	.5571000	.4407000	.5951000						
7	.6249000	.6131000	.6255000	.5057000	.6646000						
8	.6790000	.6683000	.6798000	.5600000	.7178000						
9	.7284000	.7178000	.7292000	.6114000	.7655000						
10	.7667000	.7566000	.7674000	.6515000	.8028000						
11	.8001000	.7900000	.8008000	.6888000	.8348000						
12	.8315000	.8217000	.8320000	.7246000	.8625000						
13	.8578000	.8494000	.8582000	.7598000	.8859000						
14	.8787000	.8715000	.8792000	.7879000	.9036000						
15	.8978000	.8916000	.8983000	.8124000	.9199000						
1	.0299000	.0289000	.0299000	.0215000	.0368000						
2	.1499000	.1429000	.1499000	.1057000	.1762000						
3	.2701000	.2601000	.2701000	.1972000	.3101000						
4	.3703000	.3581000	.3703000	.2785000	.4222000						
5	.4575000	.4447000	.4576000	.3508000	.5145000						
6	.5344000	.5194000	.5348000	.4215000	.5913000						
7	.5982000	.5838000	.5987000	.4826000	.6565000						
8	.6579000	.6431000	.6582000	.5387000	.7137000						
9	.7050000	.6903000	.7053000	.5864000	.7576000						
10	.7473000	.7331000	.7474000	.6313000	.7979000						
11	.7826000	.7694000	.7827000	.6691000	.8312000						
12	.8143000	.8028000	.8144000	.7039000	.8602000						
13	.8402000	.8287000	.8403000	.7356000	.8826000						
14	.8646000	.8539000	.8647000	.7673000	.9027000						
15	.8826000	.8716000	.8827000	.7903000	.9191000						
1	.0828622	.0928149									
2	.4197333	.4444624									
3	.7544151	.8158528									
4	1.0759812	1.1396685									
5	1.3500448	1.4204448									
6	1.5879577	1.6770897									
7	1.8020048	1.8936590									
8	1.9762646	2.0894381									
9	2.1348499	2.2512219									
10	2.2621322	2.3986733									
11	2.3776576	2.5282113									
12	2.4867633	2.6408755									
13	2.5822915	2.7402884									

TABLE 5.1 SAMPLE OUTPUT DATA (CONTINUED)

14	2.6566855	2.8284182
15	2.7242920	2.8998553

AVG. NO. OF RDS.

1	7.62
2	7.80
3	7.61
4	9.91
5	7.00
6	8.00
7	8.28
8	8.00
9	10.48
10	7.03

PROBABILITY VERSUS TIME

0.00000	0.00000	0.00000	0.00000	.00050	.00150	.00250	.00630	.00880	.01280
.01730	.02320	.02820	.03500	.04290	.05290	.06290	.07420	.08430	.09650
.10700	.11730	.12940	.14250	.15470	.16940	.18300	.19420	.20820	.22020
.23260	.24510	.25840	.27030	.28290	.29720	.31110	.32260	.33390	.34450
.35540	.36590	.37790	.39030	.40020	.41080	.42180	.43100	.44080	.45110
.46000	.47050	.47990	.48920	.49940	.50900	.51750	.52550	.53400	.54260
.55140									

0.00000	0.00000	0.00000	0.00000	.00050	.00150	.00240	.00620	.00870	.01260
.01700	.02270	.02760	.03440	.04190	.05180	.06140	.07240	.08220	.09410
.10430	.11390	.12540	.13810	.15010	.16460	.17740	.18860	.20230	.21360
.22600	.23820	.25090	.26310	.27550	.28960	.30320	.31410	.32540	.33570
.34600	.35670	.36820	.38050	.39000	.40030	.41070	.41980	.42950	.43930
.44800	.45830	.46750	.47680	.48690	.49660	.50520	.51390	.52290	.53160
.54050									

0.00000	0.00000	0.00000	0.00000	.00050	.00150	.00250	.00630	.00880	.01280
.01730	.02320	.02820	.03500	.04310	.05310	.06310	.07440	.08450	.09680
.10750	.11770	.12990	.14300	.15530	.17010	.18370	.19480	.20880	.22070
.23310	.24560	.25890	.27080	.28340	.29770	.31150	.32290	.33420	.34470
.35560	.36610	.37810	.39050	.40040	.41100	.42200	.43140	.44120	.45150
.46040	.47090	.48030	.48960	.49980	.50920	.51790	.52600	.53450	.54320
.55220									

0.00000	0.00000	0.00000	0.00000	.00030	.00090	.00170	.00430	.00610	.00860
.01180	.01560	.01960	.02410	.02920	.03550	.04240	.05050	.05750	.06620
.07340	.08030	.08780	.09690	.10670	.11740	.12650	.13500	.14570	.15450
.16410	.17360	.18510	.19490	.20570	.21700	.22820	.23880	.24730	.25650
.26650	.27550	.28570	.29670	.30550	.31370	.32300	.33110	.34040	.34940
.35710	.36700	.37560	.38270	.39210	.40130	.40900	.41760	.42660	.43340
.44050									

0.00000	0.00000	0.00000	0.00000	.00050	.00160	.00270	.00700	.01000	.01460
.01930	.02560	.03150	.03870	.04800	.05930	.07070	.08330	.09540	.10900
.12150	.13240	.14530	.15980	.17320	.18990	.20440	.21680	.23120	.24410
.25710	.27050	.28400	.29790	.31110	.32680	.34120	.35340	.36570	.37680
.38800	.39990	.41220	.42480	.43500	.44570	.45780	.46810	.47780	.48840
.49720	.50800	.51770	.52680	.53650	.54590	.55510	.56320	.57210	.58100
.58990									

0.00000	0.00000	0.00000	.00010	.00030	.00110	.00220	.00470	.00740	.00980
---------	---------	---------	--------	--------	--------	--------	--------	--------	--------

TABLE 5.1 SAMPLE OUTPUT DATA (CONTINUED)

.01390	.01920	.02660	.03320	.04170	.05010	.06110	.07220	.08250	.09640
.10670	.11650	.13000	.14090	.15260	.16360	.17480	.18730	.20130	.21280
.22430	.23760	.24870	.26090	.27360	.28650	.29900	.31060	.32160	.33400
.34450	.35500	.36580	.37610	.38480	.39500	.40670	.41690	.42640	.43560
.44420	.45290	.46170	.47050	.47990	.48900	.49690	.50610	.51360	.52190
.53010									
0.00000	0.00000	0.00000	.00010	.00030	.00110	.00220	.00440	.00710	.00940
.01340	.01840	.02560	.03170	.03980	.04790	.05860	.06940	.07950	.09260
.10220	.11160	.12440	.13460	.14580	.15670	.16780	.17950	.19290	.20470
.21530	.22850	.23940	.25110	.26340	.27590	.28720	.29820	.30910	.32140
.33200	.34240	.35340	.36360	.37240	.38310	.39430	.40450	.41370	.42310
.43200	.44100	.44990	.45770	.46710	.47610	.48410	.49310	.50050	.50870
.51750									
0.00000	0.00000	0.00000	.00010	.00030	.00110	.00220	.00470	.00740	.00980
.01390	.01920	.02660	.03320	.04170	.05010	.06110	.07220	.08250	.09640
.10670	.11650	.13000	.14090	.15260	.16360	.17480	.18730	.20130	.21280
.22430	.23760	.24870	.26090	.27360	.28650	.29900	.31060	.32160	.33400
.34460	.35510	.36590	.37620	.38490	.39510	.40680	.41700	.42650	.43570
.44440	.45310	.46190	.47070	.48020	.48930	.49720	.50640	.51390	.52220
.53040									
0.00000	0.00000	0.00000	.00010	.00020	.00100	.00200	.00370	.00590	.00720
.01000	.01400	.01960	.02450	.03070	.03620	.04320	.05160	.05970	.06890
.07660	.08350	.09290	.10180	.10900	.11710	.12620	.13570	.14570	.15530
.16360	.17590	.18390	.19300	.20200	.21110	.22050	.22960	.23750	.24740
.25710	.26660	.27650	.28510	.29190	.30120	.31110	.32020	.32820	.33560
.34400	.35230	.36040	.36780	.37470	.38230	.39100	.39910	.40670	.41440
.42200									
0.00000	0.00000	0.00000	.00010	.00040	.00130	.00280	.00560	.00920	.01250
.01730	.02430	.03270	.04040	.05000	.05980	.07240	.08530	.09720	.11330
.12530	.13680	.15200	.16510	.17790	.19050	.20340	.21680	.23260	.24540
.25920	.27330	.28620	.29970	.31360	.32670	.34030	.35250	.36460	.37870
.39020	.40150	.41400	.42510	.43420	.44450	.45780	.46840	.47820	.48760
.49690	.50600	.51550	.52440	.53430	.54370	.55060	.56050	.56940	.57740
.58580									

ETC. . . . FOR OTHER ANGLES

Average numbers of rounds expected to be needed to hit or kill targets consist of two sets of five numbers each. The two sets correspond to the two target orientations respectively. The ordering within each set, according to the type of kill or whether only a target hit is considered, is the same as for the ten groups of hit probabilities and kill probabilities discussed in the preceding paragraph.

Ten groups of cumulative hit probabilities and kill probabilities versus engagement time follow. Five groups apply, as before, to each target orientation. The correspondence with kill type or whether only a target hit is of concern also remains as before. Each group contains 61 numbers. These are cumulative probabilities for engagement times of 0, 2, 4, etc., 118, 120 seconds.

It is recognized that the formats used to print output probabilities and expected personnel casualties contain several unnecessary decimal places. However, all results have been consistently rounded to two decimal places for the tank effectiveness pamphlets published by the JMEM-SS Methodology and Evaluations Working Group.

The choice of 10,000 samples that was made results in the computed output quantities, mostly probabilities, being practically always accurate to within 0.005. This degree of accuracy is basically equivalent to that achievable by deterministic programs.

6. COMPUTER ASPECTS

The direct fire program is coded in FORTRAN IV.

Production runs have been made, with the program, on the CDC 7600 computer at Aberdeen Proving Ground, Maryland and the CDC 6600 computer at Oklahoma State University Field Office, Eglin Air Force Base, Florida. Also, it has recently been learned that the Oklahoma State University Field Office will use a newer CYBER 176 computer for future production runs.

Running times can vary according to various factors, e.g., the computer used and the program options exercised. A basic run, i.e., one primarily intended to simulate 10,000 engagements for several target ranges and four pairs of target orientation angles at each range, would typically require about 1 minute of computer time for each range on either the CDC 7600 or CYBER 176.

APPENDIX A

PROGRAM LISTING AND DETAILED EXPLANATIONS

PROGRAM LISTING AND DETAILED EXPLANATIONS

The principal objective of this appendix is to provide a listing of FORTRAN statements and detailed explanations for the main program. For completeness, however, subroutine NRAN and function CNORM are also listed and briefly described.

Both the listing of program statements and the corresponding detailed explanations cover several pages. Listing and explanation pages have been intermixed so that program statements and accompanying explanations are reasonably near together.

Some input quantities have already been sufficiently explained in Section 4. Additional explanations related to inputs are included only as necessary to supplement that section.

Main program lines are numbered from 1 through 1385. These lines were grouped as seemed most convenient to facilitate the explanations.

Certain program statements require no explanation. Other statements, used more than once, are covered only when they first occur.

The listing and explanations for the main program, subroutine NRAN, and function CNORM follow.

PROGRAM LISTING

```

1      PROGRAM MEWGD ( INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT, TAPE2 )
      C
      COMMON A(80)          ,AFAIL(15)          ,AKIL(61,10)      ,AX(201)
5      A      ,AY(51)        ,C(10)            ,IDCODE(10)       ,IK(50,200)
      B      ,IP(10)         ,ITAPE(80)         ,MPK(3000,8)      ,NXTEMP(4)
      C      ,NYTEMP(4)      ,PK(10)            ,PKRLFT(10)       ,XTEMPL(4)
      D      ,XTEMPH(4)      ,IMODXY(3000,4) ,YTEMPL(4)      ,Z(19,12)
      E      ,XLEFTF(4)      ,XRGHTF(4)         ,XLEFTD(4)        ,XRGHTD(4)
10     COMMON KDMSTC(5)      ,BX(5)             ,BY(5)           ,SIGX(3,5)
      A      ,SIGY(3,5)      ,NMINUS(50,2,5) ,NPLUS(50,2,5) ,COORD(2)
      B      ,TOTAL(2)       ,NPOS(50)          ,NNEG(50)         ,NCMPOS(50)
      C      ,NCMNEG(50)     ,NRFLCT(50)        ,BIASXY(2,5)      ,SIGMXY(3,2,5)
      D      ,PH(3,5)        ,PKILL(4,3,5)       ,SSIGX(4)         ,SSIGY(4)
15     COMMON BBX(4)         ,BBY(4)            ,SSIGX(4)         ,SSIGY(4)
      A      ,PPH(5)         ,PKSHOT(4,5)        ,PPKHIT(4,5)
      COMMON KTRGTC(4)       ,NCTRY(120,4)      ,NCTRXL(120,4) ,NCTRXR(120,4)
      COMMON XXB(3,6),YYB(3,6),SSIGXB(3,6),SSIGYB(3,6)
      DATA MASK11 / 3777 B /
      DATA MASK16 / 177777 B /
20     WRITE ( 6,1010 )
      1010 FORMAT ( / / )
      READ ( 5,1110 ) IDCODE
      1110 FORMAT ( 10A1 )
      WRITE ( 6,1112 ) IDCODE
25     1112 FORMAT ( 1H1, 10X,10A1 )
      WRITE ( 6,1010 )
      READ ( 5,1120 ) NRSKP ,NCASES,NRFRST,NTGT ,NRDTYP,NRD1 ,NRDS
      A      ,NADJST,NRFBS ,NDROP ,NHIT ,NPRHIT,NDTRM1,NDTRM2
30     B      ,NDTRM3,NDTRM4,NDTRM5,NHTKLL,NTCRD1,NTCRD2,NTCRD3
      C      ,NTCRD4
      1120 FORMAT ( 14I5 )
      WRITE ( 6,1122 ) NRSKP ,NCASES,NRFRST,NTGT ,NRDTYP,NRD1 ,NRDS
      A      ,NADJST,NRFBS ,NDROP ,NHIT ,NPRHIT,NDTRM1,NDTRM2
35     B      ,NDTRM3,NDTRM4,NDTRM5,NHTKLL,NTCRD1,NTCRD2,NTCRD3
      C      ,NTCRD4
      1122 FORMAT ( 10X,14I5 )
      WRITE ( 6,1020 )
      1020 FORMAT ( )
      IF ( NRSKP .EQ. 9999 ) NRSKP = 0
40     WRITE ( 6,1130 ) NRSKP ,NCASES,NRFRST,NTGT ,NRDTYP,NRD1 ,NRDS
      A      ,NADJST,NRFBS ,NDROP ,NHIT ,NPRHIT,NDTRM1,NDTRM2
      WRITE ( 6,1131 ) NDTRM3,NDTRM4,NDTRM5,NHTKLL,NTCRD1,NTCRD2,NTCRD3
      A      ,NTCRD4
45     1130 FORMAT ( 10X,39H NRSKP          VULN. TAPE FILES TO SKIP,9X,I5 /
      A      10X,27H NCASES          NO. OF CASES,21X,I5 /
      B      10X,41H NRFRST          FIRST RANGE FOR VULN. DATA,7X,I5 /
      C      10X,32H NTGT            VULN. TAPE FORMAT,16X,I5 /
      D      10X,39H NRDTYP          VULN. DATA DEP. ON RANGE,9X,I5 /
50     E      10X,38H NRD1            SINGLE ROUND ENGAGEMENT,10X,I5 /
      F      10X,31H NRDS            MAX. NO. OF RDS.,17X,I5 /
      G      10X,38H NADJST          SP. PROC. FOR MISS. RD.,10X,I5 /
      H      10X,41H NRFBS          RANGEFINDER OR BATTLESIGHT,7X,I5 /
      J      10X,39H NDROP          STANDARD DROP ADJUSTMENT,9X,I5 /
      K      10X,23H NHIT            ADJ. HIT,25X,I5 /
55     L      10X,36H NPRHIT          HIT PROB. OUTPUT ONLY,12X,I5 /
      M      10X,34H NDTRM1          DETERMINISTIC2 HIT1,14X,I5 /
      N      10X,34H NDTRM2          DET2 NO K KILL HIT1,14X,I5 )

```

EXPLANATIONS

REFERENCES TO THE LEFT
OF EXPLANATIONS ARE TO
PROGRAM LINE NUMBERS

- 1 TAPE 5 IS ASSOCIATED WITH INPUT CARDS AND TAPE 2 WITH TAPE OR DISC CONTAINING
 TARGET VULNERABILITY INPUT DATA.
- 3-- 17 THESE ARE REALLY DIMENSION STATEMENTS. OKLAHOMA STATE UNIVERSITY FIELD OFFICE
 AT EGLIN AIR FORCE BASE HAS FOUND THAT SYSTEMATIC USE OF COMMON STATEMENTS
 ENHANCES COMPUTER EFFICIENCY.
- 18-- 19 THESE DATA STATEMENTS ARE RELATED TO RETRIEVAL OF KILL PROBABILITY AND
 PERSONNEL CASUALTY INFORMATION FROM FILES CONTAINING SUCH INFORMATION IN
 PACKED FORM.
- 20-- 165 PORTION OF PROGRAM PRECEDING PROCESSING FOR ANY PARTICULAR RANGE.
- 20-- 21 SKIP 3 LINES.
- 22-- 25 READ AND WRITE INPUT CARD 1.
- 27-- 36 READ AND WRITE INPUT CARDS 2 AND 3.
- 37-- 38 SKIP 1 LINE.
- 39 NRSKP = 9999 HAS BEEN TEMPORARILY PUNCHED ON INPUT CARDS AS CONSPICUOUS ALERT
 THAT PROPER ENTRY NEEDS TO BE DETERMINED LATER. THIS IS SIMPLY MATTER OF
 CONVENIENCE. TEMPORARY VALUE 9999 CAN BE RETAINED AS INPUT IF 0 PROVES TO BE
 CORRECT ENTRY, BECAUSE OF RESETTING DONE HERE.
- 40-- 65 REWRITE INPUTS ON CARDS 2 AND 3 WITH ABBREVIATED INDICATION OF WHAT EACH
 NUMBER REPRESENTS.
- 66-- 69 IF NRDL = 1, NRDS IS IGNORED AND NOT USED. OTHERWISE, MAXIMUM NUMBER OF ROUNDS
 TO BE FIRED PER ENGAGEMENT, READ AS INPUT, MAY BE OVERRIDDEN EITHER BY LOWER
 OR UPPER BOUND. REASON FOR LOWER BOUND OF 10 ROUNDS IS INDICATED IN
 CONNECTION WITH PROGRAM LINES 1333 THROUGH 1340. UPPER BOUND OF 19 ROUNDS
 HAS BEEN ARBITRARILY SELECTED SIMPLY TO LIMIT SCOPE OF PROGRAM CALCULATIONS.
 RDS IS REAL FORM.
- 71-- 77 IF AT LEAST ONE OF CONTROLS NDTRM1 THROUGH NDTRM5 IS NOT 0, THEIR SUM NSMDTR
 IS ALSO NOT 0 AND ALL FIVE QUANTITIES ARE ENTERED IN ARRAY KDMSTC.
- 78-- 85 IF AT LEAST ONE OF CONTROLS NTCRD1 THROUGH NTCRD4 IS NOT 0, THEIR SUM NSTCRD
 IS ALSO NOT 0, ALL FOUR QUANTITIES ARE ENTERED IN ARRAY KTRGTC, AND PROGRAM
 LINES 86 THROUGH 95 ARE SKIPPED BECAUSE TAPE OR DISC WITH VULNERABILITY DATA
 IS NOT INVOLVED.
- 87-- 95 SKIP FILES AS NECESSARY ON VULNERABILITY DATA TAPE OR DISC. NSKP FILES SKIPPED
 ARE NRSKP FILES NOT APPLYING TO POUND/TARGET COMBINATION OF CONCERN AND
 POSSIBLY ADDITIONAL FILES ASSOCIATED WITH RANGES LESS THAN FIRST ONE TO BE
 CONSIDERED. STATEMENT INVOLVING GOING TO 311 IF EOF(IU)=1.0 PREVENTS MINOR
 INCONSISTENCIES IN FILE MARK LOCATION THAT ARE OCCASIONALLY ENCOUNTERED FROM

PROGRAM LISTING (CONTINUED)

```

1131 FORMAT ( 10X,25H NDTRM3      DET2 MISS1,23X,I5 /
A      10X,34H NDTRM4      DET2 OBSERVED MISS1,14X,I5 /
60      B      10X,36H NDTRM5      DET2 UNOBSERVED MISS1,12X,I5 /
C      10X,39H NHTKLL      HIT AND KILL PROB. INPUT,9X,I5 /
D      10X,32H NTCRD1      CARDS FOR TARGET1,16X,I5 /
E      10X,32H NTCRD2      CARDS FOR TARGET2,16X,I5 /
F      10X,32H NTCRD3      CARDS FOR TARGET3,16X,I5 /
65      G      10X,32H NTCRD4      CARDS FOR TARGET4,16X,I5 )

IF ( NRD1 .EQ. 1 ) GO TO 1132
IF ( NRDS .LT. 10 ) NRDS = 10
IF ( NRDS .GT. 19 ) NRDS = 19
RDS = NRDS
70      1132 CONTINUE
NSMDTR = NDTRM1 + NDTRM2 + NDTPM3 + NDTRM4 + NDTRM5
IF ( NSMDTR .EQ. 0 ) GO TO 1135
KDMSTC(1) = NDTRM1
KDMSTC(2) = NDTRM2
75      KDMSTC(3) = NDTRM3
KDMSTC(4) = NDTRM4
KDMSTC(5) = NDTRM5
1135 CONTINUE
NSTCRD = NTCRD1 + NTCRD2 + NTCRD3 + NTCRD4
80      IF ( NSTCRD .EQ. 0 ) GO TO 1145
KTRGTC(1) = NTCRD1
KTRGTC(2) = NTCRD2
KTRGTC(3) = NTCRD3
KTRGTC(4) = NTCRD4
85      GO TO 1200
1145 CONTINUE
REWIND 2
IU = 2
NSKP = NRSKP
90      IF ( NRDTYP .EQ. 1 ) NSKP = NSKP + NRFRST/500
IF ( NSKP .EQ. 0 ) GO TO 1200
CALL SKIPFE (IU,NSKP,0)
READ ( IU,3110 ) A
IF ( EOF(IU) .EQ. 1.0 ) GO TO 311
95      311 CONTINUE
1200 CONTINUE
WRITE ( 6,1010 )
READ ( 5,1210 ) PASSN ,WCELL ,XC      ,YC      ,YBASE ,YTOP ,RELT
A      ,RELF
100      1210 FORMAT ( 7F10.4 )
WRITE ( 6,1212 ) PASSN ,WCELL ,XC      ,YC      ,YBASE ,YTOP ,RELT
A      ,RELF
1212 FORMAT ( 10X,7F10.4 )
WRITE ( 6,1020 )
105      W = WCELL
IF ( WCELL .EQ. 4.0 ) GO TO 1215
W = W / 25.4
XC = XC / 25.4
YC = YC / 25.4
110      YBASE = YBASE / 25.4
IF ( YTOP .LT. 9999.0 ) YTOP = YTOP / 25.4
1215 CONTINUE
WRITE ( 6,1220 )
1220 FORMAT ( 65X,16H HOR.      VERT. )

```

EXPLANATIONS (CONTINUED)

STOPPING RUN.

- 98- 103 READ AND WRITE INPUT CARDS 4 AND 5.
- 105- 111 W IS NEEDED BECAUSE WCELL NEEDS TO BE PRESERVED AS READ FROM INPUT CARD. IF WCELL = 100.0, W, XC, YC, YBASE, AND POSSIBLY YTOP ARE ALL CONVERTED FROM MILLIMETERS TO INCHES. YTOP = 9999.0 OR ANY LARGER NUMBER INDICATES YTOP IS UNNEEDED AND TO BE IGNORED.
- 113- 124 REWRITE INPUTS ON CARDS 4 AND 5 WITH ABBREVIATED INDICATION OF WHAT EACH NUMBER REPRESENTS.
- 125 H IS HALF OF W AND CONSEQUENTLY REPRESENTS PERPENDICULAR DISTANCE FROM CENTER OF ANY TARGET CELL TO SIDES.
- 126- 127 VERTICAL COORDINATE YAIM OF INTENDED AIMPOINT CAN CORRESPOND EITHER TO APPROXIMATE CENTER OF MASS OR TO BASE OF TARGET.
- 128- 134 VALUES 2, 3, 4, AND 5 FOR NADJST HAVE BEEN USED TO DATE ONLY IN CONNECTION WITH SPECIAL STUDY MADE FOR US ARMY ARMOR SCHOOL, FORT KNOX IN 1978. REQUIREMENTS OF THAT EFFORT ARE NOT OF GENERAL INTEREST AND NEED NOT BE DISCUSSED IN DETAIL IN THIS REPORT. SINCE 5 IS LARGEST VALUE USED TO DATE FOR NADJST, CONSIDERATION IS RESTRICTED TO NADJST EQUALLING 0 OR 1 IN REMAINDER OF THESE EXPLANATIONS.
- 136- 158 NSTCRD IS NORMALLY 0 BECAUSE MOST RUNS INVOLVE TAPE OR DISC CONTAINING TARGET VULNERABILITY DATA. EXCEPTIONALLY, INPUT CARDS CONTAINING TARGET SHAPE DATA NEED TO BE READ. IF NSTCRD IS NOT 0, AT LEAST ONE OF CONTROL QUANTITIES IN KTRGTC ARRAY MUST ALSO DIFFER FROM 0. ITGT VALUES 1, 2, 3, AND 4 CORRESPOND TO TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES RESPECTIVELY. ALL COORDINATES ARE IN SAME UNIT AS WCELL. VERTICAL COORDINATE OF CELL CENTERS FOR EACH HORIZONTAL STRIP OF TARGET CELLS IS ENTERED IN NCTRY ARRAY. HORIZONTAL COORDINATES OF CENTERS OF CELLS AT LEFT AND RIGHT ENDS OF STRIP ARE STORED IN NCTRXL AND NCTRXR ARRAYS. LAST COORDINATE IN EACH SET IS IDENTIFIED BY USE OF 9999 AS NEXT ENTRY.
- 160- 165 INITIAL SETTINGS.
- 166-1382 CYCLE FOR EACH RANGE CONSIDERED.
- 166 EXCEPT WHEN SET TO INITIAL INTPL SETTING, CONTROL QUANTITY JNTPL PRESERVES VALUE OF INTPL USED IN CALCULATION CYCLE FOR PREVIOUS RANGE WHEN RANGE INTERPOLATION OF TARGET VULNERABILITY DATA MAY HAVE BEEN INVOLVED. INPUT VALUE 987 FOR INTPL IS SPECIAL SETTING ENTERED ONLY ON INPUT CARD R1 FOR FIRST RANGE CONSIDERED IN RUN WHEN MOVING TARGET OR MOVING FIRING WEAPON IS INVOLVED.
- 167- 168 BEGIN PRINTING FOR EACH RANGE ON NEW PAGE.
- 169- 170 READ AND WRITE INPUT CARD R1.
- 171- 172 CONTROL QUANTITY ISTMOV IS SET TO 1 AND COUNTER MSET IS GIVEN INITIAL SETTING IF RUN INVOLVES MOVING TARGET OR MOVING FIRING WEAPON.
- 174 PROGRAM LINES 175 THROUGH 255 ARE NORMALLY APPLICABLE BUT ARE SKIPPED FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.
- 175- 245 READ AND WRITE INPUT CARDS R2 THROUGH R8. REWRITE INPUTS ON THESE CARDS WITH INDICATION OF WHAT EACH NUMBER REPRESENTS. OPTW AND NHTKLL CONTROL REWRITING OR SKIPPING OF SEVERAL QUANTITIES THAT ARE OFTEN UNNEEDED FOR RUN AND SET TO 0 (OR LEFT BLANK) ON INPUT CARDS.

PROGRAM LISTING (CONTINUED)

```

115      WRITE ( 6,1020 )
        WRITE ( 6,1230 ) PASSN ,W      ,W      ,XC      ,YC      ,YBASE ,YTOP
      A      ,RELT ,RELF
1230  FORMAT ( 10X,36H PASSN      TGT. PERS. EXCL. CREW,7X,F10.4 /
      A      10X,34H W,W      CELL DIM. IN INCHES,19X,2F10.4 /
120      B      10X,36H XC,YC      TGT. CTR. COORD. INS.,17X,2F10.4 /
      C      10X,36H YBASE      TGT. BOT. COORD. INS.,27X,F10.4 /
      D      10X,36H YTOP      TOP APPR. COORD. INS.,27X,F10.4 /
      E      10X,35H RELT      PROB. OF REL. FLIGHT,8X,F10.4 /
      F      10X,33H RELF      PROB. OF REL. FUZE,10X,F10.4 )

125      H = W / 2.0
        YAIM = YC
        IF ( NRFBS .EQ. 2 ) YAIM = YBASE
        IF ( NADJST .LT. 2 .OR. NADJST .GT. 5 ) GO TO 1300
130      XLEFTF(1) = -1650.0 / 25.4
        XLEFTF(4) = -3050.0 / 25.4
        XLEFTD(1) = -1350.0 / 25.4
        XRGHTF(1) = 1650.0 / 25.4
        XRGHTF(4) = 3550.0 / 25.4
        XRGHTD(1) = 1450.0 / 25.4
135      1300 CONTINUE
        IF ( NSTCRD .EQ. 0 ) GO TO 2000
        WRITE ( 6,1010 )
        DO 1310 ITGT = 1,4
        IF ( KTRGTC(ITGT) .EQ. 0 ) GO TO 2000
140      WRITE ( 6,1020 )
        DO 1320 J = 1,30
        K = 4 * (J-1)
        READ ( 5,1330 ) NCTRY(K+1,ITGT),NCTRXL(K+1,ITGT),NCTRXR(K+1,ITGT)
      A      ,NCTRY(K+2,ITGT),NCTRXL(K+2,ITGT),NCTRXR(K+2,ITGT)
145      B      ,NCTRY(K+3,ITGT),NCTRXL(K+3,ITGT),NCTRXR(K+3,ITGT)
      C      ,NCTRY(K+4,ITGT),NCTRXL(K+4,ITGT),NCTRXR(K+4,ITGT)
1330  FORMAT ( 12I5 )
        WRITE ( 6,1332 ) NCTRY(K+1,ITGT),NCTRXL(K+1,ITGT),NCTRXR(K+1,ITGT)
      A      ,NCTRY(K+2,ITGT),NCTRXL(K+2,ITGT),NCTRXR(K+2,ITGT)
150      B      ,NCTRY(K+3,ITGT),NCTRXL(K+3,ITGT),NCTRXR(K+3,ITGT)
      C      ,NCTRY(K+4,ITGT),NCTRXL(K+4,ITGT),NCTRXR(K+4,ITGT)
1332  FORMAT ( 10X,12I5 )
        IF ( NCTRY(K+1,ITGT) .EQ. 9999 .OR.
      A      NCTRY(K+2,ITGT) .EQ. 9999 .OR.
155      B      NCTRY(K+3,ITGT) .EQ. 9999 .OR.
      C      NCTRY(K+4,ITGT) .EQ. 9999 ) GO TO 1310
1320 CONTINUE
1310 CONTINUE
160      2000 CONTINUE
        N RANGE = 1
        NEJECT = 0
        JNTPL = 0
        INTPL = 0
        ISPLIT = 0
        ISTMOV = 0
165      2010 IF ( NRDTYP .EQ. 1 .AND. INTPL .NE. 987 ) JNTPL = INTPL
        WRITE ( 6,2020 )
170      2020 FORMAT ( 1H1 )
        READ ( 5,1120 ) IRANGE,INTPL,IMILS
        WRITE ( 6,1122 ) IRANGE,INTPL,IMILS
        IF ( N RANGE .EQ. 1 .AND. INTPL .EQ. 987 ) ISTMOV = 1

```

PROGRAM LISTING (CONTINUED)

```

IF ( ISTMOV .EQ. 1 ) MSET = 1
WRITE ( 6,1010 )
IF ( ISTMOV .EQ. 1 ) GO TO 2200
175 READ ( 5,1210 ) FLT ,TF1 ,TFS ,XM1 ,XM2 ,AMT1 ,AMT2
A ,STD1 ,STD2 ,XB ,YB ,SIGXB ,SIGYB ,SIGXL
B ,SIGYL ,SIGXR ,SIGYR ,PROBS ,SIGXS ,SIGYS ,PGH
C ,PGS ,PGCH ,PGCS ,SGHX ,SGHY ,SGSX ,SGSY
180 D ,CDRX ,CDRY ,HSX ,HSY ,XBH ,YBH ,SIGXBH
E ,SIGYBH,XBL ,YBL ,SIGXBL,SIGYBL,XBS ,YBS
F ,SIGXBS,SIGYBS
WRITE ( 6,1212 ) FLT ,TF1 ,TFS ,XM1 ,XM2 ,AMT1 ,AMT2
A ,STD1 ,STD2 ,XB ,YB ,SIGXB ,SIGYB ,SIGXL
185 B ,SIGYL ,SIGXR ,SIGYR ,PROBS ,SIGXS ,SIGYS ,PGH
C ,PGS ,PGCH ,PGCS ,SGHX ,SGHY ,SGSX ,SGSY
D ,CDRX ,CDRY ,HSX ,HSY ,XBH ,YBH ,SIGXBH
E ,SIGYBH,XBL ,YBL ,SIGXBL,SIGYBL,XBS ,YBS
F ,SIGXBS,SIGYBS
WRITE ( 6,1010 )
190 WRITE ( 6,2110 )
2110 FORMAT ( 63X,20H TIME DATA (SECONDS),
A / 64X,19H 1ST RD. SUBS. RDS. )
WRITE ( 6,1020 )
WRITE ( 6,2120 ) FLT ,TF1 ,TFS ,XM1 ,XM2 ,AMT1 ,AMT2
195 A ,STD1 ,STD2
2120 FORMAT ( 10X,29H FLT TIME OF FLIGHT,14X,F10.4 /
A 10X,25H TF1,TFS FIXED TIME,28X,2F10.4 /
B 10X,35H XM1,XM2 MEDIAN VARIABLE TIME,18X,2F10.4 /
C 10X,27H AMT1,AMT2 MINIMUM TIME,26X,2F10.4 /
200 D 10X,33H STD1,STD2 VARIABILITY FACTOR,20X,2F10.4 )
WRITE ( 6,1020 )
IF ( IMILS .EQ. 1 ) GO TO 2125
WRITE ( 6,2130 )
2130 FORMAT ( 62X,23H ACCURACY DATA (METERS),
205 A / 66X,16H HOR. VERT. )
GO TO 2135
2125 WRITE ( 6,2140 )
2140 FORMAT ( 63X,21H ACCURACY DATA (MILS),
A / 66X,16H HOR. VERT. )
210 2135 WRITE ( 6,1020 )
WRITE ( 6,2150 ) XB ,YB ,SIGXB ,SIGYB ,SIGXL ,SIGYL ,SIGXR
A ,SIGYR ,PROBS ,SIGXS ,SIGYS
2150 FORMAT ( 10X,25H XB,YB FIXED BIAS,28X,2F10.4 /
A 10X,34H SIGXB,SIGYB VAR. BIAS STD. DEV.,19X,2F10.4 /
215 B 10X,34H SIGXL,SIGYL LAY ERROR STD. DEV.,19X,2F10.4 /
C 10X,34H SIGXR,SIGYR RD.-TO-RD.STD. DEV.,19X,2F10.4 /
D 10X,36H PROBS PROB. SENS. MISS. RD.,6X,F10.4 /
E 10X,36H SIGXS,SIGYS SENS. ERROR STD. DEV.,17X,2F10.4 )
OPTW = PGH + PGS + PGCH + PGCS + SGHX + SGHY + SGSX + SGSY + CDRX
220 A + CDRY + HSX + HSY
IF (OPTW .EQ. 0.0 ) GO TO 2155
WRITE ( 6,1010 )
WRITE ( 6,2160 ) PGH ,PGS ,PGCH ,PGCS ,SGHX ,SGHY ,SGSX
A ,SGSY ,CDRX ,CDRY ,HSX ,HSY
225 2160 FORMAT ( 10X,38H PGH GUNNER SENS. PROB. HIGH,5X,F10.4 /
A 10X,37H PGS GNR. SENS. PROB. SHORT,6X,F10.4 /
B 10X,35H PGCH G/C SENS. PROB. HIGH,8X,F10.4 /
C 10X,36H PGCS G/C SENS. PROB. SHORT,7X,F10.4 /

```


PROGRAM LISTING (CONTINUED)

```

230      D      10X,35H SGHX,SGHY      GNR. SENS. S.D. HIGH,18X,2F10.4 /
      E      10X,36H SGSX,SGSY      GNR. SENS. S.D. SHORT,17X,2F10.4 /
      F      10X,33H CDRX,CDRY      CMDR.-TD-GNR. S.D.,20X,2F10.4 /
      G      10X,33H HSX,HSY      HIT ADJ. STD. DEV.,20X,2F10.4 )

2155 CONTINUE
      IF ( NHTKLL .EQ. 0 ) GOTO 2165
235      WRITE ( 6,1020 )
      WRITE ( 6,2140 )
      WRITE ( 6,1020 )
      WRITE ( 6,2170 ) XBH ,YBH ,SIGXBH,SIGYBH,XBL ,YBL ,SIGXBL
      A      ,SIGYBL,XBS ,YBS ,SIGXBS,SIGYBS
240      2170 FORMAT ( 10X,23H XBH,YBH      BIAS HIT,30X,2F10.4 /
      A      10X,28H SIGXBH,SIGYBH STD. DEV. HIT,25X,2F10.4 /
      B      10X,29H XBL,YBL      BIAS LOST MISS,24X,2F10.4 /
      C      10X,34H SIGXBL,SIGYBL STD. DEV. LOST MISS,19X,2F10.4 /
      D      10X,31H XBS,YBS      BIAS SENSED MISS,22X,2F10.4 /
245      E      10X,36H SIGXBS,SIGYBS STD. DEV. SENSED MISS,17X,2F10.4 )

2165 CONTINUE
      IF ( INTPL .EQ. 0 ) GO TO 2175
      INCRNG = 500
      IRNG2 = IRANGE/INCRNG + 1
250      DELRNG = IRNG2*INCRNG - IRANGE
      RATIO = DELRNG / 500.0
2175 CONTINUE
      IF ( STD1 .EQ. 0.0 ) STD1 = 0.4983
      IF ( STD2 .EQ. 0.0 ) STD2 = 0.4983
255      GO TO 2300
2200 READ ( 5,1210 ) FLT ,TF1 ,TFS ,XM1 ,XM2 ,AMT1 ,AMT2
      WRITE ( 6,1212 ) FLT ,TF1 ,TFS ,XM1 ,XM2 ,AMT1 ,AMT2
      STD1 = 0.0
      STD2 = 0.0
260      WRITE ( 6,1212 ) STD1 ,STD2
      DO 2210 M = 1,3
      DO 2210 N = 1,6
      READ ( 5,2220 ) XXB(M,N) ,YYB(M,N) ,SSIGXB(M,N) ,SSIGYB(M,N)
2220 FORMAT ( 20X,4F10.4 )
265      WRITE ( 6,2222 ) XXB(M,N) ,YYB(M,N) ,SSIGXB(M,N) ,SSIGYB(M,N)
2222 FORMAT ( 30X,4F10.4 )
2210 CONTINUE
      SIGXL = 0.0
      WRITE ( 6,2230 ) SIGXL
270      2230 FORMAT ( 70X,F10.4 )
      READ ( 5,2240 ) SIGYL ,SIGXR ,SIGYR ,PROBS ,SIGXS ,SIGYS
2240 FORMAT ( 6F10.4 / / / / )
      WRITE ( 6,1212 ) SIGYL ,SIGXR ,SIGYR ,PROBS ,SIGXS ,SIGYS

2300 CONVRT = 1.0
      PI = 3.14159
      R = IRANGE
      IF ( IMILS .EQ. 0 ) GO TO 2305
      CONVRT = R*PI / 3200.0
2305 CONVRT = CONVRT * 39.37
280      IF ( ISTMOV .EQ. 1 ) GO TO 3000
      XB = XB * CONVRT
      YB = YB * CONVRT
      SIGXB = SIGXB * CONVRT
      SIGYB = SIGYB * CONVRT
285      SIGXL = SIGXL * CONVRT

```

EXPLANATIONS (CONTINUED)

- 247- 251 IF NEEDED, RANGE INTERPOLATION FACTOR RATIO IS DETERMINED. FOR EXAMPLE, RANGES OF 600 AND 2350 METERS WOULD CORRESPOND TO 0.8 AND 0.3 RESPECTIVELY. PRODUCT OF RATIO AND 500 IS DIFFERENCE IN METERS BETWEEN RANGE RANGE AND NEXT HIGHER MULTIPLE OF 500 METERS.
- 253- 254 FOR CONVENIENCE, ZEROS CAN BE USED FOR STD1 AND STD2 ON INPUT CARD R3 INSTEAD OF 0.4983 WHICH IS GENERALLY APPLICABLE. IF THIS HAS BEEN DONE, RESET STD1 AND STD2.
- 255 SKIP PROGRAM LINES 256 THROUGH 273.
- 256- 273 READ AND WRITE INPUT CARDS CONTAINING FIRST ROUND BIAS AND STANDARD DEVIATION DATA NEEDED FOR MOVING TARGET OR MOVING FIRING WEAPON RUN. SINCE TIMES ARE NOT INVOLVED, FIRST CARD CAN CONTAIN ONLY ZEROS AND STD1 AND STD2 ARE SET TO 0. DO 2210 LOOP PROCESSES SET OF 18 INPUT CARDS AND STORES DATA IN XXB, YYB, SSIGXB, AND SSIGYB ARRAYS. SINCE STANDARD DEVIATIONS ENTERED IN LATTER TWO ARRAYS ALREADY ACCOUNT FOR RANDOM ERRORS AS WELL AS OTHER ERROR CONTRIBUTORS, SIGXL IS SET TO 0. LAST CARD CAN CONTAIN ONLY ZEROS BECAUSE QUANTITIES RELATED TO SUBSEQUENT ROUND SENSING AND ADJUSTMENT AS WELL AS TO RANDOM ERRORS ARE UNNEEDED. THE 18 SETS OF INPUT BIASES AND STANDARD DEVIATIONS MAY INCLUDE DUMMY SETS FOR WHICH CALCULATIONS ARE NOT TO BE MADE. SUCH DUMMY SETS ARE IDENTIFIED BY HORIZONTAL BIAS SETTING OF 999.9999.
- 274- 279 CONVERSION FACTOR CONVRT IS SET TO APPROPRIATE VALUE FOR CHANGING METERS OR MILS TO INCHES.
- 280 SKIP PROGRAM LINES 281 THROUGH 328 FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.
- 281- 298 CONVERT FROM METERS OR MILS TO INCHES.
- 299 SKIP PROGRAM LINES 300 THROUGH 328 IF ASSOCIATED QUANTITIES ARE UNNEEDED.
- 300- 312 CONVERT FROM MILS TO INCHES. IF IMILS EQUALS 0, PREVIOUS SETTING OF CONVRT HAS NOT PROVIDED FOR CONVERSION FROM MILS TO METERS.
- 313- 328 ENTER BIASES AND STANDARD DEVIATIONS IN BBX, BBY, SSIGX, AND SSIGY ARRAYS.
- 330 SKIP PROGRAM LINES 331 THROUGH 462 IF TARGET SHAPE DATA FROM CARDS ARE NEEDED.
- 331- 462 CYCLE FOR READING AND PROCESSING TARGET VULNERABILITY DATA FROM TAPE OR DISC.
- 331- 334 DO NOT READ AND PROCESS VULNERABILITY DATA FROM TAPE OR DISC WHEN NEEDED INFORMATION HAS ALREADY BEEN READ AND PROCESSED. CONDITION INVOLVING NRANGE, INTPL, AND ISPLIT COVERS INSTANCES WHERE FIRST RANGE OF CONCERN FOR RANGE INTERPOLATION OF VULNERABILITY DATA HAS BEEN INVOLVED IN PREVIOUS RANGE CYCLE. JNTPL EQUALLING 1 INDICATES THAT SECOND RANGE USED IN INTERPOLATION OF IMMEDIATELY PRECEDING RANGE CYCLE IS RANGE OF CONCERN FOR CURRENT CYCLE. VULNERABILITY DATA THAT DO NOT VARY WITH RANGE ARE READ AND PROCESSED IN FIRST RANGE CYCLE ONLY AND CAN THEN BE REUSED.
- 335 CONDITION IS ASSOCIATED WITH RANGE INTERPOLATION OF TARGET VULNERABILITY DATA. ISPLIT EQUALLING 2 INDICATES THAT CALCULATIONS HAVE ALREADY BEEN COMPLETED FOR LESSER OF TWO RANGES BRACKETING ACTUAL RANGE AND PARTICULAR PAIR OF FORWARD AND REVERSE ORIENTATION ANGLES. IF FORWARD ANGLE OF 0 DEGREES IS INVOLVED, CONTINUE WITH PROGRAM LINES 336 THROUGH 374 BEFORE OBTAINING VULNERABILITY DATA FOR RANGE BRACKETING THAT OF TARGET ON HIGH SIDE AND FOR ANGLES OF 0 AND 180 DEGREES. IF FORWARD ANGLE IS 30, 60, OR 90 DEGREES, SKIP TO PROGRAM STATEMENT 320C.

PROGRAM LISTING (CONTINUED)

```

290  SIGYL = SIGYL * CONVRT
      SIGXR = SIGXR * CONVRT
      SIGYR = SIGYR * CONVRT
      SIGXS = SIGXS * CONVRT
      SIGYS = SIGYS * CONVRT
      SGHX = SGHX * CONVRT
      SGHY = SGHY * CONVRT
      SGSX = SGSX * CONVRT
      SGSY = SGSY * CONVRT
295  CDRX = CDRX * CONVRT
      CDRY = CDRY * CONVRT
      HSX = HSX * CONVRT
      HSY = HSY * CONVRT
      IF ( NHTKLL .EQ. 0 ) GOTO 3000
300  IF ( IMILS .EQ. 0 ) CONVRT = CONVRT * R*PI/3200.0
      XBH = XBH * CONVRT
      YBH = YBH * CONVRT
      SIGXBH = SIGXBH * CONVRT
      SIGYBH = SIGYBH * CONVRT
305  XBL = XBL * CONVRT
      YBL = YBL * CONVRT
      SIGXBL = SIGXBL * CONVRT
      SIGYBL = SIGYBL * CONVRT
      XBS = XBS * CONVRT
      YBS = YBS * CONVRT
310  SIGXBS = SIGXBS * CONVRT
      SIGYBS = SIGYBS * CONVRT
      BBX(1) = XB
      BBY(1) = YB
315  BBX(2) = XBH
      BBY(2) = YBH
      BBX(3) = XBL
      BBY(3) = YBL
      BBX(4) = XBS
320  BBY(4) = YBS
      SSIGX(1) = SQRT(SIGXB**2+SIGXL**2+SIGXR**2)
      SSIGY(1) = SQRT(SIGYB**2+SIGYL**2+SIGYR**2)
      SSIGX(2) = SIGXBH
      SSIGY(2) = SIGYBH
325  SSIGX(3) = SIGXBL
      SSIGY(3) = SIGYBL
      SSIGX(4) = SIGXBS
      SSIGY(4) = SIGYBS
      3000 CONTINUE
330  IF ( NSTCRD .GT. 0 ) GO TO 3800
      IF ( NRANGE .GT. 1 .AND. INTPL .EQ. 1 .AND. ISPLIT .EQ. 0 ) GO TO
        A 4010
      IF ( JNTPL .EQ. 1 ) GO TO 4010
      IF ( NRDTYP .EQ. 0 .AND. NRANGE .GT. 1 ) GO TO 4000
335  IF ( ISPLIT .EQ. 2 .AND. NANGLE .NE. 1 ) GO TO 3200
      WRITE ( 6,1010 )
      IF ( NEJECT .EQ. 1 ) READ ( IU,3110 ) A
3110  FORMAT ( 80A1 )
      IF ( EOF(IU) .EQ. 1.0 ) GO TO 301
340  301 CONTINUE
      IF ( ISTMOV .EQ. 1 .AND. NRANGE .NE. 1 ) READ ( IU,3110 ) A
      IF ( EOF(IU) .EQ. 1.0 ) GO TO 312

```

PROGRAM LISTING (CONTINUED)

```

312 CONTINUE
READ ( IU,3110 ) ITAPE
345 IF ( EOF(IU) .EQ. 1.0 ) GO TO 302
302 CONTINUE
WRITE ( 6,3112 ) ITAPE
3112 FORMAT ( 10X,80A1 )
DO 3120 K = 1,74
350 IF ( ITAPE(K) .NE. IDCODE(4) ) GO TO 3120
IF ( ITAPE(K+1) .NE. IDCODE(5) ) GO TO 3120
IF ( ITAPE(K+2) .NE. IDCODE(6) ) GO TO 3120
M = K+3
GO TO 3130
355 3120 CONTINUE
GO TO 3140
3130 DO 3150 L = M,77
IF ( ITAPE(L) .NE. IDCODE(7) ) GO TO 3150
IF ( ITAPE(L+1) .NE. IDCODE(8) ) GO TO 3150
360 IF ( ITAPE(L+2) .NE. IDCODE(9) ) GO TO 3150
IF ( ITAPE(L+3) .NE. IDCODE(10) ) GO TO 3150
GO TO 3160
3150 CONTINUE
3140 WRITE ( 6,3170 )
365 3170 FORMAT ( 1H0, 10X,32H PROJECTILE/TARGET CODE MISMATCH )
GO TO 9900
3160 CONTINUE
WRITE ( 6,3180 ) ( IDCODE(I),I=1,3 ),( IDCODE(I),I=4,6 )
A ( IDCODE(I),I=7,10 ),IRANGE
370 3180 FORMAT ( 24X,26H TASK SHEET IDENTIFICATION,10X,3A1 /
A 24X,16H PROJECTILE CODE,20X,3A1 /
B 24X,12H TARGET CODE,23X,4A1 /
C 24X,16H RANGE IN METERS,18X,15 )
IANGLE = 1
375 3200 IF ( ISPLIT .NE. 2 ) IC = IANGLE
IB = IC * 2
IA = IB - 1
WRITE ( 6,1010 )
READ ( IU,3110 ) A
380 IF ( EOF(IU) .EQ. 1.0 ) GO TO 303
303 CONTINUE
NSKIP = 3
WRITE ( 6,1020 )
DO 3210 L = 1,NSKIP
385 READ ( IU,3110 ) A
IF ( EOF(IU) .EQ. 1.0 ) GO TO 304
304 CONTINUE
WRITE ( 6,3112 ) A
3210 CONTINUE
390 YTEMPL(IC) = 9999.0
YTEMPH = -9999.0
XTEMPL(IC) = 9999.0
XTEMPH(IC) = -9999.0
M = 1
395 3400 IF ( NTGT .GT. 1 ) GO TO 3405
READ ( IU,3410 ) X,Y,( PKRLFT(J),J=1,4 ),( PKRLFT(J),J=6,9 )
3410 FORMAT ( 1X,F6.1,F7.1,5X,4F7.3,6X,4F7.3 )
GO TO 305
3405 IF ( NTGT .GT. 2 ) GO TO 3415

```

EXPLANATIONS (CONTINUED)

- 337- 343 SPECIAL STATEMENTS NEEDED TO READ AND IGNORE BLANK LINE OR EJECT PAGE LINE PERIODICALLY USED ON TAPE OR DISC.
- 344- 373 READ NEXT LINE OF INFORMATION FROM TAPE OR DISC. THIS LINE SHOULD CONTAIN PROJECTILE CODE, RANGE, AND TARGET CODE. VERIFY AGREEMENT OF PROJECTILE AND TARGET CODES WITH THOSE IN IDCODE. IF DISCREPANCY IS FOUND, PRINT ERROR INDICATION AND GO TO PROGRAM STATEMENT 9900 TO STOP RUN. OTHERWISE WRITE SPECIFIED REFERENCE INFORMATION.
- 374 INITIAL SETTING.
- 375- 460 CYCLE FOR IANGLE EQUALLING 1, 2, 3, OR 4. THESE VALUES CORRESPOND TO TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES RESPECTIVELY TOGETHER WITH ASSOCIATED REVERSE ANGLES.
- 375- 377 INITIAL SETTINGS.
- 379- 389 READ BLANK LINE FROM TAPE OR DISC. ALSO READ AND WRITE THREE LINES OF HEADER INFORMATION SUCH AS 0 DEG ELEV, 30 DEG AZIM ETC...
- 390- 394 INITIAL SETTINGS.
- 395- 447 CYCLE FOR EACH TARGET CELL.
- 395- 405 READ CELL CENTER COORDINATES AND RELATED VULNERABILITY DATA. FORMAT PREVIOUSLY USED TO STORE NUMBERS ON TAPE OR DISC IS IDENTIFIED BY NTGT. LABEL CELL COORDINATES AS X AND Y. WCELL INDICATES WHETHER X AND Y ARE IN INCHES OR MILLIMETERS. STORE VULNERABILITY DATA IN PKRLFT ARRAY, USING PKRLFT(1) AND PKRLFT(6) FOR M (MOBILITY) KILL PROBABILITIES, PKRLFT(2) AND (7) FOR F (FIREPOWER) KILL PROBABILITIES, (3) AND (8) FOR M OR F (MOBILITY AND/OR FIREPOWER) KILL PROBABILITIES, (4) AND (9) FOR K (COMPLETE DESTRUCTION) KILL PROBABILITIES AND IF NECESSARY (5) AND (10) FOR PASSENGER PERSONNEL CASUALTIES. PKRLFT(1) THROUGH (5) ARE ASSOCIATED WITH TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES, AND PKRLFT(6) THROUGH (10) WITH CORRESPONDING REVERSE ANGLES.
- 406- 411 NUMBER READ AS X COORDINATE OF CELL CENTER MAY EXCEPTIONALLY BE 999.9 USED ON TAPE OR DISC TO INDICATE ALL DATA FOR PARTICULAR SET OF FORWARD AND REVERSE ANGLES HAVE BEEN READ. IN THAT CASE, MULTIPLICATION OF X BY 10.0 SETS IEND TO 9999. ADDITION OF 10000.001 TO X AND Y ELIMINATES ALL MINUS SIGNS. INTEGER QUANTITIES IMODX AND IMODY ARE READILY COMBINED INTO SINGLE ENTRY STORABLE IN IMODXY ARRAY. WHEN X EQUALS 999.9, IMODX IS SET TO 19999 AND COMBINED WITH Y COORDINATE 0 BEFORE STORAGE OF RESULT IN IMODXY ARRAY. AFTER END INDICATOR IS THUS STORED, RUN CONTINUES AT PROGRAM STATEMENT 3700.
- 412- 427 IGNORE THESE SPECIAL STATEMENTS FOR NADJST EQUALLING 2 THROUGH 5.
- 428- 430 IF CELL COORDINATES ARE IN MILLIMETERS, CONVERT TO INCHES.
- 431- 434 UPDATE, AS NECESSARY, MINIMUM AND MAXIMUM COORDINATES RELATED TO RECTANGLE ENCLOSING TARGET. IF PREVIOUSLY ESTABLISHED VALUE OF YEMPL(IC) IS GREATER THAN Y, RESET YEMPL(IC) TO Y. SIMILARLY, RESET YEMPH IF LESS THAN Y, XEMPL(IC) IF GREATER THAN X, AND XEMPH(IC) IF LESS THAN X.
- 435 IF NPRHIT EQUALS 1, SKIP PROGRAM LINES 436 THROUGH 447 SINCE THEY INVOLVE UNNEEDED TARGET VULNERABILITY DATA.
- 436- 447 QUANTITIES IN PKRLFT ARRAY CONTAIN THREE DECIMAL PLACES. CONVERT TO CONVENIENT INTEGER FORM AND ENTER IN IP ARRAY. PACK FIRST FIVE IP VALUES INTO SINGLE NUMBER AND STORE RESULT IN MPK ARRAY. TARGET CELL INVOLVED IS IDENTIFIED BY M. IA EQUALS 1, 3, 5, OR 7 FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR

PROGRAM LISTING (CONTINUED)

```

400      READ ( IU,3420 ) X,Y,PKRLFT
      3420 FORMAT ( 1X,2F6.0,2(3X,4F6.2,F7.2) )
      GO TO 305
      3415 READ ( IU,3430 ) X,Y,PKRLFT
      3430 FORMAT ( 1X,F6.1,F7.1,5X,2(4F7.3,F6.1) )
405      305 IF ( EOF(IU) .EQ. 1.0 ) GO TO 3500
      3500 IEND = X * 10.0
      IMODX = X + 10000.001
      IF ( IEND .EQ. 9999 ) IMODX = 19999
      IMODY = Y + 10000.001
410      IMODXY(M,IC) = IMODX*100000 + IMODY
      IF ( IEND .EQ. 9999 ) GO TO 3700
      IF ( NADJST .EQ. 2 .AND. IANGLE .EQ. 2 ) GO TO 3600
      IF ( NADJST .EQ. 3 .AND. IANGLE .EQ. 2 ) GO TO 3600
      IF ( NADJST .EQ. 4 .AND. IANGLE .EQ. 2 ) GO TO 3600
415      IF ( NADJST .EQ. 5 .AND. IANGLE .EQ. 2 ) GO TO 3600
      IF ( NADJST .EQ. 2 .AND. IANGLE .EQ. 3 ) GO TO 3600
      IF ( NADJST .EQ. 3 .AND. IANGLE .EQ. 3 ) GO TO 3600
      IF ( NADJST .EQ. 4 .AND. IANGLE .EQ. 3 ) GO TO 3600
      IF ( NADJST .EQ. 5 .AND. IANGLE .EQ. 3 ) GO TO 3600
420      IF ( NADJST .EQ. 2 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO T
      A      0 3600
      IF ( NADJST .EQ. 3 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO T
      A      0 3600
      IF ( NADJST .EQ. 4 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO T
425      A      0 3600
      IF ( NADJST .EQ. 5 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO T
      A      0 3600
      IF ( WCELL .EQ. 4.0 ) GO TO 3505
      X = X / 25.4
430      Y = Y / 25.4
      3505 YTEMPL(IC) = AMIN1(YTEMPL(IC),Y)
      YTEMPH = AMAX1(YTEMPH,Y)
      XTEMPL(IC) = AMIN1(XTEMPL(IC),X)
      XTEMPH(IC) = AMAX1(XTEMPH(IC),X)
435      IF ( NPRHIT .EQ. 1 ) GO TO 3600
      DO 3510 K = 1,10
440      3510 IP(K) = 1000.0*PKRLFT(K) + 0.1
      MPK(M,IA) = SHIFT(IP(1),49) .OR.
      A      SHIFT(IP(2),38) .OR.
      B      SHIFT(IP(3),27) .OR.
      C      SHIFT(IP(4),16) .OR.
      D      IP(5)
      MPK(M,IB) = SHIFT(IP(6),49) .OR.
      A      SHIFT(IP(7),38) .OR.
445      B      SHIFT(IP(8),27) .OR.
      C      SHIFT(IP(9),16) .OR.
      D      IP(10)
      3600 CONTINUE
      M = M + 1
450      IF ( M .GT. 3000 ) GO TO 3605
      GO TO 3400
      3605 WRITE ( 6,3610 )
      3610 FORMAT ( 1H0, 10X,22H TARGET MATRIX TOO BIG )
      GO TO 9900
455      3700 CONTINUE
      NXTEMP(IC) = (XTEMPH(IC)-XTEMPL(IC))/W + 1.001

```


EXPLANATIONS (CONTINUED)

90 DEGREES RESPECTIVELY. SIMILARLY PACK LAST FIVE IP VALUES FOR STORAGE IN MPK ARRAY. IB IS ASSOCIATED WITH REVERSE ANGLES AND EQUALS 1 MORE THAN CORRESPONDING IA VALUE.

- 448- 454 RESET CELL COUNTER M. IF M THEN EQUALS 3001, 3000 CELLS HAVE ALREADY BEEN PROCESSED AND MAXIMUM ALLOWED 2999 CELLS HAS BEEN EXCEEDED. IF TARGET CONTAINS EXACTLY 2999 CELLS, CELL 3000 IS ASSOCIATED WITH 999.9 ENTRY. IF LIMIT HAS BEEN VIOLATED, PRINT ERROR INDICATION AND GO TO PROGRAM STATEMENT 9900 TO STOP RUN. OTHERWISE RECYCLE FOR NEXT CELL.
- 456- 457 CALCULATE NUMBER OF CELLS ALONG EACH SIDE OF RECTANGLE THAT IS JUST LARGE ENOUGH TO ENCLOSE TARGET FOR FORWARD AND REVERSE ORIENTATIONS CORRESPONDING TO IC. RECTANGLE HAS NXTEMP(IC) CELLS IN HORIZONTAL DIRECTION AND NYTEMP(IC) CELLS IN VERTICAL DIRECTION. NUMBERS OF CELLS BASED ON DIFFERENCES BETWEEN MINIMUM AND MAXIMUM COORDINATES OF CELL CENTERS ARE INCREASED BY 1.000 TO ACCOUNT FOR HALF CELLS AT EACH EDGE. ADDITION OF .001 COVERS ROUNDING INACCURACIES.
- 458 WHEN RANGE INTERPOLATION OF VULNERABILITY DATA IS INVOLVED AND TARGET RANGE IS NOT FIRST ONE CONSIDERED IN RUN, CONTINUE AT PROGRAM STATEMENT 4100 FOR EACH IANGLE VALUE.
- 459 CONTINUE AT PROGRAM STATEMENT 4000 IF IANGLE VALUES 1 THROUGH 4 HAVE ALL BEEN COVERED.
- 460 IF THIRD OF FOUR INTERPOLATION STEPS CORRESPONDING TO ISPLIT IS OF CURRENT CONCERN, CONTINUE AT PROGRAM STATEMENT 4020 FOR PARTICULAR IANGLE VALUE UNDER CONSIDERATION.
- 461- 462 SINCE IANGLE VALUES 1 THROUGH 4 HAVE NOT ALL BEEN PROCESSED, REPEAT FOR NEXT VALUE.
- 463- 505 CYCLE FOR PROCESSING TARGET SHAPE DATA READ FROM CARDS.
- 464 INITIAL SETTING.
- 465- 471 INITIAL SETTINGS. JCELL IS INTEGER FORM OF WCELL.
- 472- 473 IT VALUES 1, 2, 3, AND 4 CORRESPOND TO TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES RESPECTIVELY. COUNTER K INDICATES WHICH STRIP OF TARGET CELLS IS OF CURRENT CONCERN. STRIP CAN EXCEPTIONALLY CONSIST OF ONLY ONE CELL. SET JY TO EQUAL Y COORDINATE COMMON TO CENTERS OF ALL CELLS IN STRIP. SET JX TO EQUAL X COORDINATE OF CENTER OF CELL AT LEFT EDGE OF STRIP.
- 474- 477 ADDITION OF 10000 TO JX AND JY ELIMINATES ALL MINUS SIGNS. COMBINE IMODX AND IMODY AND STORE RESULTING QUANTITY IN IMODXY ARRAY. WHEN JX EQUALLYING 9999 INDICATES THAT ALL TARGET CELLS FOR ANGLE CORRESPONDING TO IT HAVE BEEN PROCESSED, RUN CONTINUES AT PROGRAM STATEMENT 3900.
- 478- 482 IF CELL COORDINATES ARE IN MILLIMETERS, CONVERT TO INCHES.
- 483- 486 UPDATE, AS NECESSARY, MINIMUM AND MAXIMUM COORDINATES RELATED TO RECTANGLE ENCLOSING TARGET. IF PREVIOUSLY ESTABLISHED VALUE OF YTEMP(I) IS GREATER THAN Y, RESET YTEMP(I) TO Y. SIMILARLY, RESET YTEMPH IF LESS THAN Y, XTEMP(I) IF GREATER THAN X, AND XTEMPH(I) IF LESS THAN X.
- 487 RESET CELL COUNTER.
- 488 CELL COUNTER SHOULD NEVER EXCEED 3000. IF LIMIT HAS BEEN VIOLATED, GO TO PROGRAM STATEMENT 3845.

PROGRAM LISTING (CONTINUED)

```

NYTEMP(IC) = (YTEMPH-YTEMPL(IC))/W + 1.001
IF ( INTPL .EQ. 1 .AND. NRANGE .GT. 1 ) GO TO 4100
IF ( IANGLE .EQ. 4 ) GO TO 4000
460 IF ( ISPLIT .EQ. 2 ) GO TO 4020
      IANGLE = IANGLE + 1
      GO TO 3200
      3800 CONTINUE
      IT = 1
465      3805 YTEMPL(IT) = 9999.0
      YTEMPH = -9999.0
      XTEMPL(IT) = 9999.0
      XTEMPH(IT) = -9999.0
      M = 1
470      K = 1
      JCELL = WCELL
      3810 JY = NCTRY(K,IT)
      JX = NCTRXL(K,IT)
      3820 IMODX = JX + 10000
475      IMODY = JY + 10000
      IMODXY(M,IT) = IMODX*100000 + IMODY
      IF ( JX .EQ. 9999 ) GO TO 3900
      X = JX
      Y = JY
480      IF ( WCELL .EQ. 4.0 ) GO TO 3825
      X = X / 25.4
      Y = Y / 25.4
      3825 YTEMPL(IT) = AMIN1(YTEMPL(IT),Y)
      YTEMPH = AMAX1(YTEMPH,Y)
485      XTEMPL(IT) = AMIN1(XTEMPL(IT),X)
      XTEMPH(IT) = AMAX1(XTEMPH(IT),X)
      M = M + 1
      IF ( M .GT. 3000 ) GO TO 3845
      IF ( JX .EQ. NCTRXR(K,IT) ) GO TO 3835
490      JX = JX + JCELL
      GO TO 3820
      3835 K = K + 1
      GO TO 3810
      3845 WRITE ( 6,3610 )
495      GO TO 9900
      3900 CONTINUE
      MCELLS = M - 1
      WRITE ( 6,1020 )
      WRITE ( 6,1122 ) MCELLS
500      NXTEMP(IT) = (XTEMPH(IT)-XTEMPL(IT))/W + 1.001
      NYTEMP(IT) = (YTEMPH-YTEMPL(IT))/W + 1.001
      IF ( IT .EQ. 4 ) GO TO 4000
      IT = IT + 1
      IF ( KTRGTC(IT) .EQ. 0 ) GO TO 4000
505      GO TO 3805
      4000 CONTINUE
      IF ( NSTCRD .GT. 0 ) GO TO 4200
      4010 NANGLE = 1
      4020 NALPHA = NANGLE / 2
510      NBETA = NALPHA * 2
      IF ( NBETA .EQ. NANGLE ) GO TO 4105
      IC = NALPHA + 1
      IF ( ISTMOV .NE. 1 ) GO TO 4025

```


EXPLANATIONS (CONTINUED)

- 489- 493 NCTRXR(K,IT) IS X COORDINATE OF CENTER OF CELL AT RIGHT EDGE OF STRIP. WHEN JX EQUALS THIS COORDINATE, STRIP HAS BEEN COMPLETELY PROCESSED. IN THAT CASE, RESET K TO CORRESPOND TO NEXT STRIP OF TARGET CELLS AND CONTINUE AT PROGRAM STATEMENT 3810. IN OTHER INSTANCES, RESET JX TO EQUAL X COORDINATE OF NEXT CELL IN STRIP AND BEGIN PROCESSING FOR THIS CELL AT PROGRAM STATEMENT 3820.
- 494- 495 PRINT ERROR INDICATION AND GO TO PROGRAM STATEMENT 9900 TO STOP RUN.
- 497- 499 MCELLS IS TOTAL NUMBER OF TARGET CELLS FOR ANGLE ASSOCIATED WITH IT. CELL COUNTER M IS REDUCED BY 1 BECAUSE END INDICATOR HAS BEEN INCLUDED. WRITE MCELLS FOR POSSIBLE USE IN CHECKING RUN OUTPUT.
- 500- 501 CALCULATE NUMBER OF CELLS ALONG EACH SIDE OF RECTANGLE THAT IS JUST LARGE ENOUGH TO ENCLOSE TARGET FOR ORIENTATION CORRESPONDING TO IT. EXPLANATIONS FOR PROGRAM LINES 456 AND 457 APPLY HERE ALSO IF IC IS REPLACED BY IT.
- 502 CONTINUE AT PROGRAM STATEMENT 4000 IF IT VALUES 1 THROUGH 4 HAVE ALL BEEN COVERED.
- 503- 505 RESET IT FOR NEXT ORIENTATION ANGLE. KTRGTC(IT) CAN EQUAL 0 ONLY IF RUN INVOLVES FEWER THAN FOUR ANGLES. IN THAT CASE, CONTINUE AT PROGRAM STATEMENT 4000. OTHERWISE BEGIN PROCESSING FOR NEW ORIENTATION AT PROGRAM STATEMENT 3805.
- 507 SKIP PROGRAM LINES 508 THROUGH 532 IF RUN DOES NOT INVOLVE VULNERABILITY DATA FROM TAPE OR DISC.
- 508 INITIAL SETTING.
- 509- 510 NANGLE EQUALS 1, 3, 5, OR 7 FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR 90 DEGREES RESPECTIVELY AND 2, 4, 6, OR 8 FOR CORRESPONDING REVERSE ANGLE. NALPHA EQUALS 0 WHEN NANGLE IS 1 OR 1 WHEN NANGLE IS 2. CORRESPONDING VALUES OF NBETA ARE 0 OR 2 RESPECTIVELY FOR NANGLE EQUALLING 1 OR 2. NBETA ALWAYS DIFFERS FROM NANGLE FOR FORWARD ORIENTATION ANGLES AND EQUALS NANGLE FOR REVERSE ANGLES.
- 511 SKIP PROGRAM LINES 512 THROUGH 542 WHEN NANGLE CORRESPONDS TO REVERSE ANGLE.
- 512 IC IS SET TO 1, 2, 3, OR 4 RESPECTIVELY FOR NANGLE EQUALLING 1, 3, 5, OR 7.
- 513 PROGRAM LINES 514 THROUGH 523 APPLY ONLY FOR MOVING TARGET OR MOVING FIRING WEAPON RUN AND ARE SKIPPED OTHERWISE.
- 514 IF DUMMY SET FOR WHICH NO CALCULATIONS ARE NEEDED IS INVOLVED, SKIP PROGRAM LINES 515 THROUGH 1374.
- 515- 523 INITIAL SETTINGS.
- 524- 528 IGNORE STATEMENTS APPLICABLE ONLY FOR NADJST EQUALLING 2 THROUGH 5.
- 530- 531 INITIAL SETTINGS.
- 532 SKIP PROGRAM LINES 533 THROUGH 537 APPLICABLE ONLY WHEN RUN INVOLVES TARGET SHAPE DATA FROM CARDS.
- 533- 537 SPECIAL SETTINGS ARE NEEDED WHEN TARGET SHAPE DATA FROM CARDS ARE USED.
- 534 INITIAL SETTING.
- 535- 537 SET IC, NANGLE, AND NBETA SO THAT PROGRAM STATEMENT 4100 AND SUBSEQUENT

PROGRAM LISTING (CONTINUED)

```

4035 IF ( XXB(IC,MSET) .EQ. 999.9999 ) GO TO 9305
515   BBX(1) = XXB(IC,MSET) * CONVRT
      BBY(1) = YYB(IC,MSET) * CONVRT
      SSIGX(1) = SSIGXB(IC,MSET) * CONVRT
      SSIGY(1) = SSIGYB(IC,MSET) * CONVRT
      DO 4040 N = 2,4
520   BBX(N) = 0.0
      BBY(N) = 0.0
      SSIGX(N) = 0.0
      SSIGY(N) = 0.0
4040
4025 IF ( NADJST .LT. 2 .OR. NADJST .GT. 5 ) GO TO 4045
525   IF ( IC .EQ. 2 .OR. IC .EQ. 3 ) NANGLE = NANGLE + 1
      IF ( IC .EQ. 2 .OR. IC .EQ. 3 ) GO TO 9100
      IF ( IC .EQ. 4 .AND. YBASE .GT. 0.0 ) NANGLE = NANGLE + 1
      IF ( IC .EQ. 4 .AND. YBASE .GT. 0.0 ) GO TO 9100
4045 CONTINUE
530   IB = IC * 2
      IA = IB - 1
      GO TO 4100
4200 CONTINUE
      NTRGTC = 1
535   4210 IC = NTRGTC
      NANGLE = 0
      NBETA = 9
4100 NX = NXTEMP(IC)
540   NY = NYTEMP(IC)
      CNX = NX
      CNY = NY
      XCORN = XTEMPL(IC)
4105 IF ( NBETA .EQ. NANGLE ) XCORN = -XCORN
      DO 4110 I = 1,NX
545   U = I - 1
      4110 AX(I) = XCORN + U*W
      DO 4120 J = 1,NY
      V = J - 1
      4120 AY(J) = YTEMPL(IC) + V*W
550   DO 4130 I = 1,NX
      DO 4130 J = 1,NY
      4130 IK(J,I) = 0
      DO 4140 M = 1,3000
      IMODX = IMODXY(M,IC)/100000
555   IMODY = IMODXY(M,IC) - IMODX*100000
      X = IMODX - 10000
      IEND = X
      IF ( IEND .EQ. 9999 ) GO TO 4145
      IF ( NBETA .EQ. NANGLE ) X = -X
560   Y = IMODY - 10000
      IF ( WCELL .EQ. 4.0 ) GO TO 4155
      X = X / 25.4
      Y = Y / 25.4
      4155 I = (X-XCORN)/W + 1.001
565   J = (Y-YTEMPL(IC))/W + 1.001
      4140 IK(J,I) = M
      4145 CONTINUE
      IF ( NHTKLL .EQ. 9 ) GOTO 7400
      IF ( NSTCRD .GT. 0 ) GO TO 4300
570   IF ( INTPL .EQ. 0 .OR. ISPLIT .EQ. 0 ) GO TO 4300

```

EXPLANATIONS (CONTINUED)

INSTRUCTIONS APPLY FOR TARGET SHAPE CARD INPUT AS WELL AS FOR VULNERABILITY DATA INPUT FROM TAPE OR DISC. SELECTION OF ARBITRARY BUT DIFFERENT VALUES FOR NANGLE AND NBETA ENSURES CALCULATIONS NORMALLY ASSOCIATED WITH REVERSE ANGLES ARE NOT ATTEMPTED.

- 538- 541 NX AND NY ARE SET TO EQUAL NUMBERS OF CELLS ON EDGES OF SMALLEST RECTANGLE ENCLOSING TARGET FOR IC VALUE OF CURRENT CONCERN. CNX AND CNY ARE REAL FORMS.
- 542 XCORN R IS SMALLEST X COORDINATE CORRESPONDING TO CENTER OF AT LEAST ONE TARGET CELL. FOR EXAMPLE, IF PREVIOUS CALCULATIONS HAVE RESULTED IN XTEMPL(IC) BEING -204 AND XTEMPH(IC) 128 FOR IC VALUE OF INTEREST, XCORN R EQUALS -204.
- 543 XCORN R NEEDS TO BE RESET FOR REVERSE ANGLE. FOR EXAMPLE, IF XTEMPL(IC) EQUALS -204 AND XTEMPH(IC) 128, CORRECT SETTING FOR XCORN R IS NOW -128.
- 544- 549 AX AND AY ARRAYS NEED TO CONTAIN X AND Y COORDINATES RESPECTIVELY OF CENTERS OF CELLS IN SMALLEST RECTANGLE ENCLOSING TARGET. ARRAYS MAY POSSIBLY INCLUDE SOME VALUES FOR WHICH THERE IS NO CORRESPONDING TARGET CELL.
- 550- 552 INITIAL SETTINGS.
- 553- 566 COORDINATES OF CENTER OF EACH TARGET CELL ARE RETRIEVED AND CONVERTED TO PAIR OF INDICES J AND I THAT IDENTIFY CELL LOCATION IN RECTANGLE ENCLOSING TARGET. ONCE PROCESSING IS DONE FOR ALL CELLS, IK ARRAY CONTAINS 1) ZEROS FOR VALUES OF J AND I ASSOCIATED WITH CELLS OUTSIDE TARGET, AND 2) CELL COUNTER INDEX M FOR J AND I PAIRS CORRESPONDING TO TARGET CELLS. USE OF INDICES J AND I IN IK ARRAY PARALLELS EARLIER USE OF THESE SAME INDICES IN AY AND AX ARRAYS RESPECTIVELY.
- 568 SKIP PROGRAM LINES 569 THROUGH 1132 IF NHTKLL INDICATES RUN DOES NOT INVOLVE SIMULATED FIRING ENGAGEMENTS.
- 569- 570 SKIP PROGRAM LINES 571 THROUGH 574 UNLESS ISPLIT EQUALLING 1, 2, OR 3 INDICATES FIRST, SECOND, OR THIRD OF FOUR SETS OF SIMULATED ENGAGEMENTS INVOLVED IN RANGE INTERPOLATION HAVE BEEN COMPLETED.
- 571- 574 ISPLIT EQUALLING 1 INDICATES FIRST SET OF SIMULATED ENGAGEMENTS INVOLVED IN RANGE INTERPOLATION HAS BEEN COMPLETED. FIRST SET IS FOR FORWARD ORIENTATION ANGLE OF CONCERN. RESETTNG OF ISAMP TO 0 BY PROGRAM STATEMENT 5000 IS NECESSARY BEFORE SIMULATION OF ENGAGEMENTS FOR REVERSE ANGLE CAN BEGIN. IF ISPLIT EQUALS 2 OR 3, NEND1 ENGAGEMENTS HAVE ALREADY BEEN SIMULATED FOR BOTH FORWARD AND REVERSE ANGLES. IF NECESSARY, RESET ISAMP TO NEND1 BEFORE NEXT SET OF ENGAGEMENTS IS INITIATED.
- 576 BASIC ADJUSTMENT PROCEDURE DOES NOT INVOLVE PROGRAM LINES 577 AND 578.
- 577- 578 INITIAL SETTINGS.
- 580 NSMDTR EQUALLING 0 INDICATES PROGRAM LINES 581 THROUGH 585 ARE TO BE SKIPPED.
- 581- 585 INITIAL SETTINGS.
- 587 PROGRAM LINES 588 THROUGH 643 ARE OF POSSIBLE CONCERN FOR FORWARD ORIENTATION ANGLE OF TARGET BUT NOT FOR REVERSE ANGLE.
- 588 PROGRAM LINES 589 THROUGH 597 ARE NEVER INVOLVED AFTER PROCESSING FOR FIRST PAIR OF TARGET ORIENTATION ANGLES HAS BEEN COMPLETED.
- 589- 597 ENGAGEMENT IS TO BE REPEATEDLY SIMULATED TOTAL OF NSAMP TIMES FOR EACH SET OF CONDITIONS. EACH SIMULATED ENGAGEMENT IS CALLED SAMPLE ENGAGEMENT OR SIMPLY

PROGRAM LISTING (CONTINUED)

```

IF ( ISPLIT .EQ. 1 ) GO TO 5000
IF ( ISPLIT .EQ. 2 ) GO TO 5100
ISAMP = NEND1
GO TO 5100
575      4300 CONTINUE
IF ( NADJST .EQ. 0 ) GO TO 4305
DO 4310 I = 1, NRDS
      4310 AFAIL(I) = 0.0
      4305 CONTINUE
580      IF ( NSMDTR .EQ. 0 ) GO TO 4400
DO 4320 N = 1, 5
DO 4320 I = 1, 2
DO 4320 J = 1, 50
NMINUS(J, I, N) = 0
585      4320 NPLUS(J, I, N) = 0
      4400 CONTINUE
IF ( NBETA .EQ. NANGLE ) GO TO 5000
IF ( NANGLE .GT. 1 ) GO TO 4500
NSAMP = 10000
SAMP = NSAMP
WRITE ( 6, 4410) NSAMP
4410 FORMAT ( / /, 10X, 21H NUMBER OF SAMPLES = , I6 )
IF ( NSTCRD .GT. 0 ) GO TO 4415
IF ( INTPL .EQ. 1 ) GO TO 4425
595      4415 NEND1 = NSAMP
GO TO 4500
4425 IF ( NANGLE .EQ. 1 ) NEND1 = RATIO * SAMP
      4500 CONTINUE
IF ( NSTCRD .GT. 0 ) GO TO 4600
600      IF ( NRANGE .GT. 1 ) GO TO 4600
IF ( NANGLE .GT. 1 ) GO TO 4600
DROP = 0.0
IF ( NDROP .EQ. 0 ) GO TO 4600
IF ( NDROP .GT. 1 ) GO TO 4510
605      DROP = (YTOP-YBASE) * 0.5
GO TO 4600
4510 IF ( NADJST .NE. 2 .AND. NADJST .NE. 4 ) GO TO 4600
PI = 3.14159
R = IRANGE
610      CNMTER = R*PI / 3200.0
CNINCH = CNMTER * 39.37
IF ( NDROP .GT. 2 ) GO TO 4520
DROP = 0.5 * CNINCH
GO TO 4600
615      4520 IF ( NDROP .GT. 3 ) GO TO 4530
DROP = 1.0 * CNINCH
GO TO 4600
4530 IF ( NDROP .GT. 4 ) GO TO 4540
DROP = 2.0 * CNINCH
GO TO 4600
620      4540 IF ( NDROP .GT. 5 ) GO TO 4550
DFLCTN = 1.0 * CNINCH
GO TO 4600
4550 IF ( NDROP .GT. 6 ) GO TO 4560
625      DFLCTN = 2.5 * CNINCH
GO TO 4600
4560 DFLCTN = 5.0 * CNINCH

```


EXPLANATIONS (CONTINUED)

SAMPLE IN THESE EXPLANATIONS. SAMP IS REAL FORM. NEND1 REPRESENTS NUMBER OF ENGAGEMENTS THAT REQUIRE CONSIDERATION AS PART OF FIRST, AND POSSIBLY ONLY, GROUP PROCESSED. NEND1 IS SET EITHER TO NSAMP OR, IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS INVOLVED, TO APPROPRIATE FRACTION OF NSAMP. IN LATTER CASE PROGRAM STATEMENT 6015 SUBSEQUENTLY CAUSES REMAINING PORTION OF NSAMP ENGAGEMENTS TO BE ACCOUNTED FOR.

- 599- 601 PROGRAM LINES 602 THROUGH 627 CAN BE OF CONCERN ONLY WHEN FIRST RANGE AND FIRST PAIR OF TARGET ORIENTATION ANGLES ARE BEING PROCESSED. CONDITION INVOLVING NSTCRD IS INCLUDED BECAUSE SPECIAL SETTINGS OF NANGLE AND NBETA ESTABLISHED BY PROGRAM LINES 536 AND 537 WHEN RUN INVOLVES TARGET SHAPE DATA FROM CARDS WOULD OTHERWISE CAUSE PROBLEM.
- 602 INITIAL SETTING.
- 603 SKIP PROGRAM LINES 604 THROUGH 627 IF NDRDP IS 0.
- 604- 627 RESET STANDARD VERTICAL ADJUSTMENT DROP TO HALF OF TARGET HEIGHT FOR NDRDP EQUALLING 1. NDRDP VALUES 2 THROUGH 6 ARE ASSOCIATED WITH NADJUST EQUALLING 2 THROUGH 5. IGNORE CORRESPONDING PROGRAM STATEMENTS.
- 629- 634 INITIAL SETTINGS.
- 635- 643 CONDITIONS OF INTEREST INCLUDE PAIR OF TARGET ORIENTATION ANGLES REPRESENTED BY NANGLE AND NVRSE OR PARTICULAR TARGET ASSOCIATED WITH NTRGTC.
- 644 INITIAL SETTING BEFORE ANY SAMPLE ENGAGEMENTS FOR PARTICULAR CONDITIONS.
- 645- 892 CYCLE FOR EACH SAMPLE ENGAGEMENT SIMULATED.
- 645- 653 INITIAL SETTINGS FOR PARTICULAR SAMPLE ENGAGEMENT BEING SIMULATED.
- 654- 656 R1 AND R2 ARE RANDOM NORMAL DEVIATES DRAWN FROM NORMAL DISTRIBUTION WITH MEAN OF 0 AND STANDARD DEVIATION OF 1. CALCULATED VALUES OF XC1 AND YC1 ARE COORDINATES OF POINT IN TARGET COORDINATE SYSTEM WHERE FIRST ROUND WOULD IMPACT IF THERE WERE NO RANDOM ERRORS. XC1 IS SUM OF 1) HORIZONTAL COORDINATE XC OF INTENDED AIMPOINT, 2) HORIZONTAL FIXED BIAS XB, AND 3) HORIZONTAL VARIABLE BIAS DETERMINED FOR PARTICULAR FIRING ENGAGEMENT OF CONCERN BY APPLYING R1 AS ADJUSTMENT FACTOR TO VARIABLE BIAS STANDARD DEVIATION SIGXB. SIMILARLY FOR YC1.
- 657- 658 INITIAL SETTINGS.
- 659- 891 CYCLE FOR EACH ROUND FIRED.
- 659- 660 INITIAL SETTINGS.
- 661- 669 COORDINATES X1 AND Y1 OF ROUND IMPACT POINT IN PLANE OF TARGET ARE DETERMINED. FAC IS CONTROL THAT CAN EQUAL ONLY 0 OR 1. FAC IS INITIALLY SET TO 1 TO INDICATE THAT NO ADJUSTMENT BASED ON SENSING HAS YET OCCURRED, AND RESET TO 0 AFTER FIRST SUCH ADJUSTMENT. LAY ERRORS ARE EXCLUDED FROM FURTHER CONSIDERATION WHEN ADJUSTMENT BASED ON SENSING HAS BEEN MADE, BECAUSE ASSOCIATED SENSING ERRORS ARE DEFINED TO INCLUDE LAY ERRORS AS WELL AS ROUND OBSERVATION ERRORS. HORIZONTAL LAY ERROR X2, IF APPLICABLE, IS GOTTEN BY APPLYING R1 TO HORIZONTAL LAY ERROR STANDARD DEVIATION SIGXL. SIMILARLY FOR VERTICAL LAY ERROR Y2. HORIZONTAL RANDOM ERROR XRE ACCOUNTS FOR LAY ERROR, IF NECESSARY, AND ALWAYS INCLUDES HORIZONTAL ROUND-TO-ROUND ERROR DETERMINED, FOR SPECIFIC ROUND BEING CONSIDERED, BY APPLYING R1 TO HORIZONTAL ROUND-TO-ROUND STANDARD DEVIATION SIGXR. SIMILARLY FOR VERTICAL RANDOM ERROR YRE. COORDINATES X1 AND Y1 OF ACTUAL IMPACT POINT ARE OBTAINED BY ADJUSTING XC1 AND YC1 TO REFLECT CONTRIBUTION OF RANDOM ERRORS.

PROGRAM LISTING (CONTINUED)

	<u>4600</u>	CONTINUE
		DO 4610 J = 1,10
630		DO 4610 I = 1,61
	4610	AKIL(I,J) = 0.0
		DO 4620 J = 1,12
		DO 4620 I = 1,NRDS
	4620	Z(I,J) = 0.0
635		IF (NSTCRD .GT. 0) GO TO 4640
		NRVRSE = NANGLE + 1
		WRITE (6,4630) NANGLE,NRVRSE
	4630	FORMAT (/ /, 10X,10H ANGLES = ,2I7)
		WRITE (6,1020)
640		GO TO 5000
	4640	WRITE (6,4650) NTRGTC
	4650	FORMAT (/ /, 10X,10H TARGET = ,I7)
		WRITE (6,1020)
	<u>5000</u>	ISAMP = 0
645	5100	ISAMP = ISAMP + 1
		T = FLT
		SUMCASE = 0.0
		XC1 = 0.0
		YC1 = 0.0
650		IHW = 0
		NFAIL = 0
		DO 5110 J = 1,10
	5110	C(J) = 0.0
		CALL NRAN(R1,R2)
655		XC1 = XC1 + XC + XB + R1*SIGXB
		YC1 = YC1 + YAIM + YB + R2*SIGYB
		FAC = 1.0
		J = 0
	5200	J = J + 1
660		NSHORT = 0
		IF (FAC .EQ. 0.0) GO TO 5205
		CALL NRAN(R1,R2)
		X2 = R1 * SIGXL
		Y2 = R2 * SIGYL
665	5205	CALL NRAN(R1,R2)
		XRE = FAC*X2 + R1*SIGXR
		YRE = FAC*Y2 + R2*SIGYR
		X1 = XC1 + XRE
		Y1 = YC1 + YRE
670		CALL NRAN(T1,T2DUM)
		IF (J .GT. 1) GO TO 5215
		HWM = XM1 * EXP(T1*STD1)
		IF (HWM .LT. AMT1) HWM = AMT1
		T = T + TF1 + HWM
675		GO TO 5220
	5215	HWM = XM2 * EXP(T1*STD2)
		IF (HWM .LT. AMT2) HWM = AMT2
		T = T + TFS + HWM
	<u>5220</u>	CONTINUE
680		J10 = 2.0 + T/2.0
		IF (NADJST .LT. 2 .OR. NADJST .GT. 5) GO TO 5225
		IF (WCELL .EQ. 100.0 .AND. YBASE .GT. 0.0) GO TO 5235
		IF (XLEFTF(IC) .LE. X1 .AND. X1 .LE. XRGHTF(IC)) GO TO 5245
		IF (NADJST .EQ. 2 .OR. NADJST .EQ. 3) GO TO 5665

EXPLANATIONS (CONTINUED)

- 670- 678 ENGAGEMENT TIME T IS RESET TO EQUAL TIME AT WHICH ROUND UNDER CONSIDERATION REACHES TARGET RANGE. SECOND RANDOM NORMAL DEViate T2DUM IS UNNEEDED AND IGNORED. DISTINCTION IS MADE BETWEEN FIRST ROUND AND SUBSEQUENT ROUNDS. FIRST ROUND FIRING TIME, MEASURED FROM BEGINNING OF ENGAGEMENT, INCLUDES FIXED TIME COMPONENT TF1 THAT MAY EQUAL 0. VARIABLE COMPONENT, WHICH IS TOTAL FIRING TIME IF FIXED TIME EQUALS 0, IS GOTTEN FROM LOGARITHMICONORMAL DISTRIBUTION WITH MEDIAN TIME XM1 AND VARIABILITY FACTOR ST1. HWM REPRESENTS SPECIFIC VARIABLE TIME GENERATED FROM DISTRIBUTION OF TIMES BY APPLICATION OF T1. IF INITIAL VALUE OF HWM IS EVER LESS THAN MINIMUM TIME AMT1, LATTER VALUE OVERRIDES. UPDATED VALUE OF T IS TIME AT WHICH FIRST ROUND HITS OR MISSES TARGET, BECAUSE FLIGHT TIME FLT HAS ALREADY BEEN ACCOUNTED FOR BY INITIAL SETTING. NOTE THAT PROGRAM DOES NOT PROCESS FLIGHT TIME AND FIRING TIME OF FIRST ROUND IN ORDER MATCHING CHRONOLOGICAL SEQUENCE OF BATTLE EVENTS, SINCE FIRING OF ROUND OBVIOUSLY PRECEDES ITS FLIGHT TOWARD TARGET. FIRING TIME FOR EACH SUBSEQUENT ROUND IS ESTABLISHED BASICALLY LIKE FIRST ROUND FIRING TIME. EACH SUBSEQUENT ROUND FIRING TIME IS CONSIDERED MEASURED FROM TIME AT WHICH PREVIOUS ROUND IS FIRED. SUBSEQUENT ROUND FIRING TIME ACCOUNTS FOR FIXED TIME COMPONENT THAT MAY AGAIN BE 0. VARIABLE TIME COMPONENT, WHICH MAY BE TOTAL FIRING TIME, IS GOTTEN FROM LOGARITHMICONORMAL DISTRIBUTION WITH MEDIAN TIME XM2 AND VARIABILITY FACTOR ST2. HWM REPRESENTS SPECIFIC VARIABLE TIME BASED ON T1. IF NECESSARY, INITIAL VALUE OF HWM IS OVERRIDDEN BY MINIMUM TIME AMT2. UPDATED VALUE OF T IS TIME AT WHICH SUBSEQUENT ROUND OF INTEREST HITS OR MISSES TARGET. ANOTHER OBSERVATION IS USEFUL. SUPPOSE, FOR EXAMPLE, THAT FOURTH ROUND IS BEING PROCESSED. VALUE OF T PRIOR TO UPDATING IS TIME AT WHICH THIRD ROUND HITS OR MISSES TARGET. STRICTLY SPEAKING, ONE NEEDS TO SUBTRACT PROJECTILE FLIGHT TIME TO GET TIME AT WHICH THIRD ROUND IS FIRED, ADD FOURTH ROUND FIRING TIME, AND THEN ADD TIME OF FLIGHT FOR FOURTH ROUND. FIRST AND THIRD OF THESE STEPS CLEARLY CANCEL EACH OTHER OUT AND ARE CONSEQUENTLY NOT EXPLICITLY REQUIRED.
- 680 TIME T IS CONVERTED TO INDEX J10 ASSOCIATED WITH AKIL ARRAY. J10 EQUALLING 1 IS RESERVED FOR 0 SECONDS, RATHER THAN FOR ANY INTERVAL. SUBSEQUENT INTEGER VALUES OF J10 CORRESPOND TO TIME INTERVALS OF 0 TO 2 SECONDS (EXCLUDING BOTH 0 AND 2 SECONDS), 2 TO 4 SECONDS (EXCLUDING 4 SECONDS), ETC . . . , RESPECTIVELY. ASSUME, FOR EXAMPLE, THAT T EQUALS 47.8 SECONDS. THEN, $T/2$ EQUALS 23.9, AND $23.9 + 2$ EQUALS 25.9. SINCE J10 IS INTEGER QUANTITY, IT IS SET TO 25.
- 681- 694 IGNORE THESE SPECIAL STATEMENTS FOR NADJST EQUALLING 2 THROUGH 5.
- 696- 710 DETERMINE WHETHER ROUND HITS TARGET.
- 696- 701 ANY ROUND FOR WHICH VERTICAL COORDINATE OF IMPACT POINT IS LESS THAN VERTICAL COORDINATE YBASE DEFINING TARGET BASE MISSES TARGET. WHEN NADJST EQUALS 1, NSHORT IS SET TO 1 TO INDICATE THAT PARTICULAR MISSING ROUND UNDER CONSIDERATION HAS BEEN SHORT OF TARGET. FIRE ADJUSTMENT PROCEDURE ASSOCIATED WITH NADJST EQUALLING 0 DOES NOT INVOLVE DISTINGUISHING WHETHER MISSING ROUND IS SHORT OR NOT.
- 703 IGNORE.
- 704 HORIZONTAL COORDINATE OF IMPACT POINT IS SMALLER THAN SMALLEST X COORDINATE ASSOCIATED WITH VERTICAL RECTANGLE ENCLOSING TARGET. ROUND MISSES TO LEFT.
- 705 ROUND MISSES TO RIGHT.
- 706 ROUND IS TOO LOW TO HIT TARGET. ALTHOUGH COMPARISON INVOLVING YBASE HAS BEEN MADE EARLIER, IT IS POSSIBLE YBASE AND AY(1)-H DIFFER SLIGHTLY DUE TO ROUNDING.

PROGRAM LISTING (CONTINUED)

685		IF (NADJUST .EQ. 5) GO TO 5625
		IF (X1 .LT. XLEFTF(IC)) XC1 = XC1 + DFLCTN
		IF (X1 .GT. XRGHTF(IC)) XC1 = XC1 - DFLCTN
		GO TO 5800
	5235	IF (XLEFTD(IC) .LE. X1 .AND. X1 .LE. XRGHTD(IC)) GO TO 5245
690		IF (NADJUST .EQ. 2 .OR. NADJUST .EQ. 3) GO TO 5665
		IF (NADJUST .EQ. 5) GO TO 5625
		IF (X1 .LT. XLEFTD(IC)) XC1 = XC1 + DFLCTN
		IF (X1 .GT. XRGHTD(IC)) XC1 = XC1 - DFLCTN
		GO TO 5800
695	5225	CONTINUE
		IF (NADJUST .EQ. 1) GO TO 5255
		IF (Y1 .LT. YBASE) GO TO 5600
		GO TO 5245
	5255	IF (Y1 .GE. YBASE) GO TO 5245
700		NSHORT = 1
		GO TO 5600
	5245	CONTINUE
		IF (NADJUST .EQ. 4 .OR. NADJUST .EQ. 5) GO TO 5400
		IF (X1 .LT. AX(1)-H) GO TO 5600
705		IF (X1 .GT. AX(NX)+H) GO TO 5600
		IF (Y1 .LT. AY(1)-H) GO TO 5600
		IF (Y1 .GT. AY(NY)+H) GO TO 5600
		JV = MIN1((Y1-AY(1)+H)/W + 1.0,CNY)
		IH = MIN1((X1-AX(1)+H)/W + 1.0,CNX)
710		IF (IK(JV,IH) .LE. 0) GO TO 5600
		IF (J .GT. 1) GO TO 5265
		IF (INTPL .EQ. 1) GO TO 5265
		IF (NDTRM1 .EQ. 0 .AND. NDTRM2 .EQ. 0) GO TO 5265
		COORD(1) = X1 - XRE - XC
715		COORD(2) = Y1 - YRE - YC
		DO 5270 I = 1,2
		IF (COORD(I) .GE. 0.0) GO TO 5275
		NCOORD = -COORD(I)/20.0 + 1.0
		IF (NCOORD .GT. 50) NCOORD = 50
720		DO 5280 N = 1,2
		IF (KDMSTC(N) .EQ. 0) GO TO 5280
		NMINUS(NCOORD,I,N) = NMINUS(NCOORD,I,N) + 1
	5280	CONTINUE
		GO TO 5270
725	5275	NCOORD = COORD(I)/20.0 + 1.0
		IF (NCOORD .GT. 50) NCOORD = 50
		DO 5290 N = 1,2
		IF (KDMSTC(N) .EQ. 0) GO TO 5290
		NPLUS(NCOORD,I,N) = NPLUS(NCOORD,I,N) + 1
730	5290	CONTINUE
	5270	CONTINUE
	5265	CONTINUE
		IF (RANF(DUM) .GT. RELT) GO TO 5700
		IF (NHIT .EQ. 0) GO TO 5400
735		CALL NRAN(R1,R2)
		XC1 = XC1 - X1 + XC - R1*HSX
		YC1 = YC1 - Y1 + YC - R2*HSY
		FAC = 0.0
	5400	CONTINUE
740		IF (IHW .GT. 0) GO TO 5405
		IHW = 1

EXPLANATIONS (CONTINUED)

- 707 ROUND MISSES HIGH.
- 708-- 710 ROUND HITS WITHIN RECTANGLE ENCLOSING TARGET. IMPACT POINT IS WITHIN CELL WHOSE CENTER HAS Y AND X COORDINATES EQUAL TO JV AND IH RESPECTIVELY. FORMULAS FOR JV AND IH SYSTEMATICALLY RESOLVE AMBIGUITIES THAT ARISE, EXCEPTIONALLY, IF IMPACT POINT IS COMMON TO TWO OR FOUR CELLS. FOLLOWING ILLUSTRATION SHOULD CLARIFY FORMULA FOR JV. 1) $Y1 - (AY(1) - H)$, WHICH EQUALS $Y1 - AY(1) + H$, IS DISTANCE IN INCHES FROM IMPACT POINT TO BOTTOM EDGE OF RECTANGLE. LET THIS DISTANCE EQUAL 22.415 INCHES. 2) DIVISION BY CELL DIMENSION W CONVERTS FROM INCHES TO CORRESPONDING NUMBER OF CELLS. LET W EQUAL 3.937 INCHES. THEN 22.415 INCHES EQUAL 5.693 CELLS. 3) FOR EXAMPLE CHOSEN, IMPACT POINT OBVIOUSLY LIES IN SIXTH ROW OF CELLS. SINCE JV IS INTEGER QUANTITY, ANY DECIMAL FRACTION SUCH AS .693 IS EVENTUALLY DROPPED FROM CALCULATION AND ADDITION OF 1 TO GET 6.693 IS NECESSARY. INTEGER VALUE 6 FOR JV IS OBTAINED BY DROPPING .693. COMPARISON OF 6.693 TO CNY ENSURES THAT MAXIMUM POSSIBLE VALUE NY IS NEVER EXCEEDED DUE TO ROUNDING. SIMILAR EXPLANATIONS APPLY TO IH. PREVIOUS PROCESSING OF TARGET DESCRIPTION AND VULNERABILITY DATA HAS SET IK ARRAY VALUES TO BE POSITIVE IF AND ONLY IF CORRESPONDING CELLS ARE INCLUDED IN TARGET. ROUND MISSES IF IT IMPACTS ON CELL WHICH, ALTHOUGH IN RECTANGLE ENCLOSING TARGET, IS NOT PART OF TARGET.
- 711-- 713 PROGRAM LINES 714 THROUGH 731 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH AT LEAST ONE OF CONTROLS NDTRM1 AND NDTRM2 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF ROUND INDEX J INDICATES THAT SOME SUBSEQUENT ROUND RATHER THAN FIRST ROUND IS BEING PROCESSED OR IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS NEEDED.
- 714-- 715 COORD(1) AND COORD(2) RESPECTIVELY ARE ESSENTIALLY HORIZONTAL AND VERTICAL MISS DISTANCES IN TARGET PLANE WITH REFERENCE TO APPROXIMATE CENTER OF MASS OF TARGET. TO VERIFY THIS, SEE HOW XC1 AND YC1 ARE CALCULATED BY PROGRAM LINES 655 AND 656 AND HOW X1 AND Y1 ARE SET BY LINES 668 AND 669. COORD(1) IS DIFFERENCE BETWEEN X COORDINATE OF APPROXIMATE CENTER OF MASS AND X COORDINATE OF POINT THAT WOULD BE HIT REPEATEDLY IF THERE WERE NO RANDOM ERRORS AND WEAPON FIRED SEVERAL ROUNDS WITHOUT ANY ADJUSTMENT BETWEEN ROUNDS. SIMILARLY, COORD(2) IS DIFFERENCE OF CORRESPONDING Y COORDINATES.
- 716-- 731 INDEX I VALUES 1 AND 2 ARE ASSOCIATED WITH PROCESSING OF HORIZONTAL AND VERTICAL MISS DISTANCES RESPECTIVELY. PROGRAM LINES 718 THROUGH 723 APPLY TO NEGATIVE COORD(I) VALUES, WHILE LINES 725 THROUGH 730 COVER POSITIVE VALUES OR 0. QUANTITIES IN NMINUS AND NPLUS ARRAYS ARE COUNTERS INDICATING NUMBERS OF ENGAGEMENTS FOR WHICH MISS DISTANCE FALLS WITHIN ANY 20-INCH INTERVAL. TOTAL SPREAD COVERED IS BASICALLY FROM -1000.0 TO 1000.0 (EXCLUDING -1000.0 AND 1000.0) INCHES. ANY MISS DISTANCE OUTSIDE THIS SPREAD WOULD BE COUNTED AS BEING WITHIN INTERVAL NUMBER 50 ASSOCIATED WITH NMINUS OR NPLUS ARRAY. N EQUALLING 1 CORRESPONDS TO ALL FIRST ROUNDS THAT HIT TARGET. CALCULATIONS FOR N EQUAL TO 2 ARE IDENTICAL AT THIS STAGE TO THOSE FOR N EQUAL TO 1 BUT EVENTUALLY APPLY TO FIRST ROUND HITS THAT DO NOT RESULT IN K (COMPLETE DESTRUCTION) KILL OF TARGET.
- 733 RANDOM NUMBER RANF(DUM) IS COMPARED TO PROBABILITY RELT THAT ROUND HAS FLOWN RELIABLY TO TARGET RANGE. DEFECTS CAUSING ERRATIC FLIGHT OF ROUND ARE CONSIDERED TO MAKE IT IMPOSSIBLE FOR ROUND TO HIT AND FOR FIRE ADJUSTMENT TO BE ATTEMPTED. PROCESSING CONTINUES AT PROGRAM STATEMENT 5700 AFTER DETERMINATION OF DEFECTIVE TRAJECTORY.
- 734 SKIP PROGRAM LINES 735 THROUGH 738 IF NHIT CONTROL INDICATES AIMPOINT IS NOT TO BE ADJUSTED AFTER TARGET HIT.
- 735-- 738 ADJUSTMENT OF AIMPOINT AFTER TARGET HIT IS CONSIDERED BASED ON GUNNER SENSING OF IMPACT. UPDATED VALUES OF XC1 AND YC1 ARE COORDINATES OF POINT IN TARGET COORDINATE SYSTEM WHERE NEXT ROUND WOULD IMPACT IF THERE WERE NO RANDOM

EXPLANATIONS (CONTINUED)

ERRORS. XC1 IS OBTAINED BY COMBINING 1) HORIZONTAL COORDINATE XC OF INTENDED AINPOINT, 2) DIFFERENCE XC1-X1 WHICH INVOLVES XC1 AND X1 VALUES FROM EARLIER CALCULATIONS AND WHICH, AS CAN BE SEEN FROM PROGRAM LINE 668, CAUSES SPECIFIC HORIZONTAL RANDOM ERRORS THAT AFFECTED IMPACT POINT OF HITTING ROUND TO BE REMOVED, AND 3) ADJUSTMENT ERROR OBTAINED BY APPLYING R1 TO HORIZONTAL STANDARD DEVIATION HSX. TERM ACCOUNTING FOR ADJUSTMENT ERROR INVOLVES MINUS SIGN BECAUSE, IF HITTING ROUND IS JUDGED TO BE OFF TARGET CENTER IN ONE DIRECTION, WEAPON IS MOVED IN OPPOSITE DIRECTION. FORMULA FOR YC1 OBVIOUSLY PARALLELS THAT FOR XC1. FAC IS RESET SO THAT LAY ERRORS, CONSIDERED INCLUDED AS PART OF ADJUSTMENT ERRORS, WILL NO LONGER BE TREATED EXPLICITLY.

- 740-- 741 IF IHW EQUALS 0, RESET TO 1. IHW CAN BE ONLY 0 OR 1, LATTER INDICATING THAT TARGET HAS BEEN HIT AT LEAST ONCE IN PARTICULAR SAMPLE ENGAGEMENT UNDER CONSIDERATION. ONCE IHW IS SET TO 1, IT REMAINS UNCHANGED FOR REMAINDER OF ENGAGEMENT.
- 742-- 748 UPDATE Z AND AKIL ARRAYS TO ACCOUNT FOR TARGET HIT BEING PROCESSED. SET INDEX KH TO 5 FOR 0, 30, 60, OR 90 DEGREES OR TO 10 FOR REVERSE ANGLE MATCHED WITH EACH FIRST ANGLE. EACH Z(K,5) OR Z(K,10) VALUE REPRESENTS HOW MANY TIMES FIRST TARGET HIT OCCURRED EITHER ON ROUND K OR ON EARLIER ROUND IN SAMPLE ENGAGEMENTS PROCESSED SO FAR. INDEX J10 ASSOCIATED WITH AKIL ARRAY IS RESTRICTED AT THIS POINT TO MAXIMUM VALUE OF 61 TO PRECLUDE FURTHER CONSIDERATION OF HITS THAT OCCUR AT TIMES EQUALLING OR EXCEEDING LIMIT OF 120 SECONDS (2 MINUTES). AKIL ARRAY IS UPDATED TO ACCOUNT FOR TIME AT WHICH HIT UNDER CONSIDERATION OCCURS. EACH AKIL(K,5) OR AKIL(K,10) VALUE REPRESENTS HOW MANY TIMES TARGET HAS BEEN HIT AT LEAST ONCE PRIOR TO TIME EQUALLING 2(K-1) SECONDS IN SAMPLE ENGAGEMENTS PROCESSED SO FAR. ANY PARTICULAR ENGAGEMENT DOES NOT CONTRIBUTE TO AKIL(K,5) OR AKIL(K,10) VALUE IF TARGET IS NOT HIT AT ALL OR IF IT IS FIRST HIT AT TIME EQUALLING OR EXCEEDING 2(K-1) SECONDS.
- 749 SKIP PROGRAM LINES 750 THROUGH 891 IF NPRHIT INDICATES TARGET HIT ONLY IS OF CONCERN BUT KILLS ARE NOT. ENGAGEMENT IS OVER SINCE FIRST HIT ON TARGET HAS BEEN ACHIEVED.
- 750 IT IS CONSIDERED THAT TARGET CANNOT BE KILLED IF, FOR ROUNDS WITH FUZE, LATTER DOES NOT PERFORM RELIABLY WHEN TARGET IS HIT. INPUT PROBABILITY RELF IS SIMPLY SET EQUAL TO 1.0000 FOR ANY ROUND TYPE THAT DOES NOT INVOLVE FUZING. PROCESSING CONTINUES AT PROGRAM STATEMENT 5700 AFTER DETERMINATION OF DEFECTIVE FUZE FUNCTIONING.
- 751-- 784 KILLING EFFECTS THAT RESULT FROM TARGET BEING HIT BY PARTICULAR ROUND OF CONCERN, EXCEPT FOR PASSENGER PERSONNEL CASUALTIES CONSIDERED LATER, ARE DETERMINED.
- 751-- 753 INITIAL SETTINGS. HW2 IS USED FOR TEMPORARY STORAGE OF RANDOM NUMBER NEEDED SUBSEQUENTLY TO DETERMINE WHETHER OR NOT TARGET IS KILLED AS RESULT OF BEING HIT. K22 IS USED FOR TEMPORARY STORAGE OF IK(JV,IH) VALUE ASSOCIATED WITH TARGET CELL HIT. N IS INVOLVED IN UNPACKING OF ARRAY MPK QUANTITIES.
- 754-- 772 UNPACK MPK ARRAY QUANTITY THAT CORRESPONDS TO TARGET CELL HIT AND ASSOCIATED TARGET ORIENTATION TO RETRIEVE PROBABILITIES OF M KILL, F KILL, M OR F KILL, AND K KILL PER HIT AND, IF NECESSARY, EXPECTED CASUALTIES PER HIT. STORE THESE IN PK ARRAY, USING PK(1) OR PK(6) FOR M KILL PROBABILITY, PK(2) OR PK(7) FOR F KILL PROBABILITY, PK(3) OR PK(8) FOR M OR F KILL PROBABILITY, PK(4) OR PK(9) FOR K KILL PROBABILITY, AND PK(5) OR PK(10) FOR CASUALTIES. PK(1) THROUGH PK(5) ARE USED FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR 90 DEGREES, AND PK(6) THROUGH PK(10) FOR CORRESPONDING REVERSE ANGLE.
- 773-- 784 CONSIDER KILL CRITERIA IN TURN. INDEX K21 EQUALS 1 OR 6 FOR M KILL, 2 OR 7 FOR

PROGRAM LISTING (CONTINUED)

```

KH = 5
IF ( NBETA .EQ. NANGLE ) KH = 10
DO 5410 K = J, NRDS
745      5410 Z(K, KH) = Z(K, KH) + 1.0
      IF ( J10 .GT. 61 ) GO TO 5405
      DO 5420 K = J10, 61
      5420 AKIL(K, KH) = AKIL(K, KH) + 1.0
      5405 IF ( NPRHIT .EQ. 1 ) GO TO 6000
750      IF ( RANF(DUM) .GT. RELF ) GO TO 5700
      HW2 = RANF(DUM)
      K22 = IK(JV, IH)
      N = -49
      DO 5430 K = 1, 4
755      IF ( NBETA .EQ. NANGLE ) GO TO 5435
      IST = SHIFT(MPK(K22, IA), N) .AND. MASK11
      ST = IST
      PK(K) = 0.001 * ST
      GO TO 5430
760      5435 IST1 = SHIFT(MPK(K22, IB), N) .AND. MASK11
      ST1 = IST1
      PK(K+5) = 0.001 * ST1
      5430 N = N + 11
765      IF ( NBETA .EQ. NANGLE ) GO TO 5445
      IST = MPK(K22, IA) .AND. MASK16
      ST = IST
      PK(5) = 0.001 * ST
      GO TO 5450
      5445 IST1 = MPK(K22, IB) .AND. MASK16
770      ST1 = IST1
      PK(10) = 0.001 * ST1
      5450 CONTINUE
      DO 5460 KILL = 1, 4
775      K21 = KILL
      IF ( NBETA .EQ. NANGLE ) K21 = K21+5
      IF ( C(K21) .GT. 0.0 ) GO TO 5460
      IF ( PK(K21) .LT. HW2 ) GO TO 5460
      C(K21) = 1.0
      DO 5490 K = J, NRDS
780      5490 Z(K, K21) = Z(K, K21) + 1.0
      IF ( J10 .GT. 61 ) GO TO 5460
      DO 5480 K = J10, 61
      5480 AKIL(K, K21) = AKIL(K, K21) + 1.0
      5460 CONTINUE
785      IF ( J .GT. 1 ) GO TO 5505
      IF ( INTPL .EQ. 1 ) GO TO 5505
      IF ( NDTRM2 .EQ. 0 ) GO TO 5505
      KILL = 4
      IF ( NBETA .EQ. NANGLE ) KILL = KILL + 5
790      IF ( C(KILL) .EQ. 0.0 ) GO TO 5505
      N = 2
      COORD(1) = X1 - XRE - XC
      COORD(2) = Y1 - YRE - YC
      DO 5510 I = 1, 2
795      IF ( COORD(I) .GE. 0.0 ) GO TO 5515
      NCOORD = -COORD(I)/20.0 + 1.0
      IF ( NCOORD .GT. 50 ) NCOORD = 50
      NMINUS(NCOORD, I, N) = NMINUS(NCOORD, I, N) - 1

```


EXPLANATIONS (CONTINUED)

F KILL, 3 OR 8 FOR M OR F KILL, AND 4 OR 9 FOR K KILL. VALUES 1 THROUGH 4 APPLY TO TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES, WHILE 6 THROUGH 9 APPLY FOR ASSOCIATED REVERSE ANGLES. EACH QUANTITY IN C ARRAY CAN BE ONLY 0 OR 1, LATTER VALUE INDICATING TARGET HAS BEEN KILLED FOR ANGLE UNDER CONSIDERATION AND KILL CRITERION CORRESPONDING TO K21. NO FURTHER PROCESSING IS TO BE DONE FOR PARTICULAR ANGLE AND CRITERION WHEN RELATED C VALUE ALREADY EQUALS 1. IF TARGET KILL HAS NOT ALREADY BEEN ACHIEVED BY EARLIER ROUND, FOR SPECIFIC COMBINATION OF ANGLE AND CRITERION, RANDOM NUMBER HW2 AND APPLICABLE KILL PROBABILITY PK(K21) ARE COMPARED TO DETERMINE WHETHER TARGET IS KILLED. IF TARGET KILL IS ACHIEVED, RESET C(K21) AND UPDATE Z AND AKIL ARRAYS ACCORDINGLY. Z AND AKIL ARRAY UPDATING IS VERY SIMILAR TO THAT ALREADY EXPLAINED FOR PROGRAM LINES 742 THROUGH 748. EACH Z(K,K21) VALUE REPRESENTS HOW MANY TIMES TARGET ORIENTED AS INDICATED BY K21 HAS BEEN KILLED ACCORDING TO CRITERION ASSOCIATED WITH K21 EITHER ON ROUND K OR ON EARLIER ROUND IN SAMPLE ENGAGEMENTS PROCESSED SO FAR. EACH AKIL(K,K21) VALUE REPRESENTS HOW MANY TIMES TARGET HAS BEEN KILLED PRIOR TO TIME EQUALLING 2(K-1) SECONDS.

- 765- 787 PROGRAM LINES 788 THROUGH 803 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH NDTRM2 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF ROUND INDEX J INDICATES THAT SOME SUBSEQUENT ROUND RATHER THAN FIRST ROUND IS BEING PROCESSED OR IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS NEEDED.
- 768- 790 SET K KILL TO EQUAL 4 FOR FORWARD ANGLE OR 9 FOR REVERSE ANGLE. IF C(KKILL) INDICATES K KILL OF TARGET HAS NOT BEEN ACHIEVED, SKIP PROGRAM LINES 791 THROUGH 803 BECAUSE HORIZONTAL AND VERTICAL MISS DISTANCES HAVE ALREADY BEEN ACCOUNTED FOR BY LINES 714 THROUGH 731.
- 791- 803 CALCULATIONS APPLY ONLY IF K KILL HAS BEEN INFLICTED ON TARGET. SINCE MISS DISTANCES ALREADY PROCESSED BY LINES 714 THROUGH 731 ARE NOT TO BE COUNTED, CORRESPONDING COUNTERS IN NMINUS ARRAY AND/OR NPLUS ARRAY ARE REDUCED ACCORDINGLY.
- 805- 828 PROCESSING FOR HITTING ROUND CONTINUES WITH ACCOUNTING FOR PASSENGER PERSONNEL CASUALTIES, AS NECESSARY, AND DETERMINATION OF WHETHER ENGAGEMENT HAS BEEN COMPLETED.
- 805- 806 INITIAL SETTINGS.
- 807- 828 NONZERO VALUE OF PASSN INDICATES PASSENGER PERSONNEL CASUALTIES NEED TO BE CONSIDERED. EXPECTED CASUALTIES PER HIT HAVE ALREADY BEEN STORED IN PK(5) FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR 90 DEGREES, OR IN PK(10) FOR ASSOCIATED REVERSE ANGLE. RATIO CASLT/PASSN INDICATES WHAT FRACTION OF PASSENGER PERSONNEL CARRIED IN TARGET VEHICLE WOULD BECOME CASUALTIES FROM EFFECTS OF ROUND BEING PROCESSED IF NO CASUALTY HAD BEEN CREDITED TO ANY PREVIOUS ROUND. DIFFERENCE PASSN-SUMCASE, WHICH EQUALS ORIGINAL NUMBER OF PASSENGER PERSONNEL PASSN IF TOTAL CASUALTIES SUMCASE INFLICTED BY PREVIOUS ROUNDS EQUAL ZERO, REPRESENTS HOW MANY PASSENGER PERSONNEL HAVE NOT ALREADY BECOME CASUALTIES. UPDATE SUMCASE TO ACCOUNT FOR ADDITIONAL CASUALTIES, REASONABLY ESTIMATED AS PRODUCT OF RATIO CASLT/PASSN AND DIFFERENCE PASSN-SUMCASE, THAT RESULT FROM ROUND OF CURRENT CONCERN. UPDATE Z ARRAY SO THAT Z(J,11), OR Z(J,12) FOR REVERSE ANGLE, REPRESENTS TOTAL NUMBER OF PASSENGER PERSONNEL CASUALTIES INFLICTED, IN ALL SAMPLE ENGAGEMENTS PROCESSED SO FAR, BY FIRST J ROUNDS. FIRST THREE CONDITIONAL STATEMENTS IN DO 5550 LOOP ENSURE CONSIDERATION OF PROPER K VALUES, BE THEY 1 THROUGH 4 OR 6 THROUGH 9. IF C(K) EVER EQUALS 0, ENGAGEMENT IS STILL INCOMPLETE UNLESS CURRENT PROCESSING INVOLVES LAST OF NRDS ROUNDS ALLOWED AS MAXIMUM. IF ALL FOUR C(K) VALUES OF CONCERN EQUAL 1, PROCEED TO NEXT ENGAGEMENT BUT ONLY AFTER UPDATING, AS NECESSARY, CUMULATIVE PERSONNEL CASUALTIES IN Z ARRAY FOR ROUNDS WHICH NEED NOT BE FIRED IN CURRENT ENGAGEMENT.

PROGRAM LISTING (CONTINUED)

```

800      5515 GO TO 5510
          NCOORD = COORD(I)/20.0 + 1.0
          IF ( NCOORD .GT. 50 ) NCOORD = 50
          NPLUS(NCOORD,I,N) = NPLUS(NCOORD,I,N) - 1
          5510 CONTINUE
          5505 CONTINUE
805      KCAS = 5
          IF ( NBETA .EQ. NANGLE ) KCAS = 10
          IF ( PASSN .LE. 0.0 ) GO TO 5545
          CASLT = PK(KCAS)
          SUMCASE = SUMCASE + (CASLT/PASSN)*(PASSN-SUMCASE)
810      IF ( NBETA .EQ. NANGLE ) GO TO 5535
          Z(J,11) = Z(J,11) + SUMCASE
          GO TO 5545
          5535 Z(J,12) = Z(J,12) + SUMCASE
          5545 DO 5550 K = 1,10
815      IF ( K .EQ. 5 .OR. K .EQ. 10 ) GO TO 5550
          IF ( K .GT. KCAS ) GO TO 5550
          IF ( KCAS .EQ. 10 .AND. K .LT. 5 ) GO TO 5550
          IF ( C(K) .EQ. 0.0 ) GO TO 5800
          5550 CONTINUE
820      IF ( J .EQ. NRDS ) GO TO 6000
          JNXT = J + 1
          DO 5560 K = JNXT,NRDS
          IF ( NBETA .EQ. NANGLE ) GO TO 5565
825      Z(K,11) = Z(K,11) + SUMCASE
          GO TO 5560
          5565 Z(K,12) = Z(K,12) + SUMCASE
          5560 CONTINUE
          GO TO 6000
          5600 CONTINUE
830      IF ( J .GT. 1 ) GO TO 5605
          IF ( INTPL .EQ. 1 ) GO TO 5605
          IF ( NDTRM3 .EQ. 0 ) GO TO 5605
          N = 3
          COORD(1) = X1 - XRE - XC
835      COORD(2) = Y1 - YRE - YC
          DO 5610 I = 1,2
          IF ( COORD(I) .GE. 0.0 ) GO TO 5615
          NCOORD = -COORD(I)/20.0 + 1.0
          IF ( NCOORD .GT. 50 ) NCOORD = 50
840      NMINUS(NCOORD,I,N) = NMINUS(NCOORD,I,N) + 1
          GO TO 5610
          5615 NCOORD = COORD(I)/20.0 + 1.0
          IF ( NCOORD .GT. 50 ) NCOORD = 50
          NPLUS(NCOORD,I,N) = NPLUS(NCOORD,I,N) + 1
845      5610 CONTINUE
          5605 CONTINUE
          IF ( NADJUST .NE. 2 ) GO TO 5625
          IF ( Y1 .LT. YBASE ) GO TO 5635
          YC1 = YC1 - DROP
850      GO TO 5800
          5635 CONTINUE
          YC1 = YC1 + DROP
          GO TO 5800
          5625 CONTINUE
855      CALL NRAN(R1,R2)

```

EXPLANATIONS (CONTINUED)

830-- 884 CYCLE FOR EACH ROUND THAT IS FIRED, FLIES RELIABLY, AND MISSES TARGET.

B30-- B32 PROGRAM LINES B33 THROUGH B45 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH NDTRM3 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF ROUND INDEX J INDICATES THAT SOME SUBSEQUENT ROUND RATHER THAN FIRST ROUND IS BEING PROCESSED OR IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS NEEDED.

833-- B45 N EQUALLING 3 CORRESPONDS TO ALL FIRST ROUNDS THAT MISS TARGET. MISS DISTANCES FOR SUCH ROUNDS ARE USED FOR SETTING COUNTERS IN NMINUS AND NPLUS ARRAYS IN SAME MANNER THAT MISS DISTANCES FOR FIRST ROUNDS HITTING TARGET ARE PROCESSED BY PROGRAM LINES 714 THROUGH 731.

B47-- B53 IGNORE STATEMENTS APPLICABLE ONLY FOR NADJUST EQUALLING 2.

855 RANDOM NORMAL DEVIATES ARE OBTAINED FOR POSSIBLE LATER USE IN PROGRAM LINES B5B AND 859 OR LINES B75 AND B76.

856 PROGRAM LINES B57 THROUGH 860 APPLY FOR BASIC ADJUSTMENT PROCEDURE AND ARE SKIPPED IF NADJUST IS 1.

857-- 860 IF NADJUST EQUALS 0, RANDOM NUMBER IS COMPARED TO PROBABILITY PROBS OF ROUND BEING SENSED. IF ROUND IS NOT SENSED, BURST-ON-TARGET ADJUSTMENT IS NOT MADE AND PROCESSING CONTINUES AT PROGRAM STATEMENT 5700. OTHERWISE DETERMINE ADJX AND ADJY. THESE TWO QUANTITIES, RELATED TO BURST-ON-TARGET ADJUSTMENT, ARE EXPLAINED IN CONNECTION WITH PROGRAM LINES 882 THROUGH 884 WHERE PROCESSING CONTINUES.

B61-- 881 ADJX AND ADJY ARE DETERMINED FOR NADJUST EQUALLING 1. TWO QUANTITIES, RELATED TO BURST-ON-TARGET ADJUSTMENT, ARE EXPLAINED IN CONNECTION WITH PROGRAM LINES 882 THROUGH 884.

B61-- B64 HIGH EQUALS 0 IF MISSING ROUND IS SHORT OF TARGET, 1 OTHERWISE. HIGH AND SHORT ARE REAL FORMS. PRSCG IS SET TO APPLICABLE PROBABILITY OF SENSING FOR GUNNER AND/OR COMMANDER.

B65-- B72 RANDOM NUMBER RANF(DJM) IS STORED IN RANDOM FOR REUSE IN PROGRAM LINE 87B. COMPARE RANDOM TO PROBABILITY OF ROUND BEING SENSED BY GUNNER AND/OR COMMANDER. PROCESSING CONTINUES AT PROGRAM STATEMENT 5655 IF ROUND IS SENSED. OTHERWISE NUMBER NFAIL OF UNSENSED ROUNDS IS UPDATED. IF NFAIL THEN EQUALS 1, DROP AIMPOINT BY HALF TARGET HEIGHT BEFORE CONSIDERATION OF NEXT ROUND. TWO FAILURES TO SENSE CAUSE THIS OUTCOME TO BE RECORDED IN AFAIL ARRAY AND ENGAGEMENT TO BE ENDED.

873-- B81 SET SGX AND SGY TO APPLICABLE HORIZONTAL AND VERTICAL SENSING ERROR STANDARD DEVIATIONS FOR GUNNER, DETERMINE CORRESPONDING PARTICULAR ERRORS ADJX AND ADJY, AND SET PRSG TO APPLICABLE PROBABILITY OF ROUND BEING SENSED BY GUNNER. COMPARE RANDOM TO GUNNER SENSING PROBABILITY TO ESTABLISH WHETHER GUNNER OR COMMANDER SHOULD BE CREDITED WITH SENSING. IF GUNNER SENSED ROUND, ADJX AND ADJY ARE ALREADY CORRECT. OTHERWISE ADJUSTMENTS ARE MADE TO ACCOUNT FOR ADDITIONAL ERRORS ASSOCIATED WITH SENSING OF ROUND BY COMMANDER WITH INFORMATION TRANSMITTAL TO GUNNER.

BB2-- BB4 THESE STATEMENTS COMPLETE ACCOUNTING FOR BURST-ON-TARGET ADJUSTMENT BASED ON SENSING. UPDATED VALUES OF XC1 AND YC1 ARE COORDINATES OF POINT IN TARGET COORDINATE SYSTEM WHERE NEXT ROUND WOULD IMPACT IF THERE WERE NO RANDOM ERRORS. XC1 IS OBTAINED BY COMBINING 1) HORIZONTAL COORDINATE XC OF INTENDED AIMPOINT, 2) DIFFERENCE XC1-X1 WHICH INVOLVES XC1 AND X1 VALUES FROM EARLIER CALCULATIONS AND WHICH, AS CAN BE SEEN FROM PROGRAM LINE 668, CAUSES SPECIFIC HORIZONTAL RANDOM ERRORS THAT AFFECTED IMPACT POINT OF SENSED MISSING ROUND TO BE REMOVED, AND 3) ADJX VALUE RELATED TO BURST-ON-TARGET ADJUSTMENT. WHEN NADJUST EQUALS 0, ADJX HAS BEEN OBTAINED BY APPLYING R1 TO

PROGRAM LISTING (CONTINUED)

		IF (NADJST .EQ. 1) GO TO 5645
		IF (RANF(DUM) .GT. PROBS) GO TO 5700
		ADJX = R1 * SIGXS
		ADJY = R2 * SIGYS
860		GO TO 5650
	5645	NHIGH = 1 - NSHORT
		HIGH = NHIGH
		SHORT = NSHORT
		PRSCG = HIGH*PGCH + SHORT*PGCS
865		RANDOM = RANF(DUM)
		IF (RANDOM .LE. PRSCG) GO TO 5655
		NFAIL = NFAIL + 1
		IF (NFAIL .EQ. 2) GO TO 5665
		YC1 = YC1 - DROP
870		GO TO 5800
	5665	AFAIL(J) = AFAIL(J) + 1.0
		GO TO 6000
	5655	SGX = HIGH*SGHX + SHORT*SGSX
		SGY = HIGH*SGHY + SHORT*SGSY
875		ADJX = R1 * SGX
		ADJY = R2 * SGY
		PRSG = HIGH*PGH + SHORT*PGS
		IF (RANDOM .LE. PRSG) GO TO 5650
		CALL NRAN(R3,R4)
880		ADJX = ADJX + R3*CDRX
		ADJY = ADJY + R4*CDRY
	5650	XC1 = XC1 - X1 + XC - ADJX
		YC1 = YC1 - Y1 + YC - ADJY
		FAC = 0.0
885	5700	IF (PASSN .LE. 0.0) GO TO 5800
		IF (NADJST .NE. 0) GO TO 5800
		IF (NBETA .EQ. NANGLE) GO TO 5735
		Z(J,11) = Z(J,11) + SUMCASE
		GO TO 5800
890	5735	Z(J,12) = Z(J,12) + SUMCASE
	5800	IF (J .LT. NRDS) GO TO 5200
	6000	CONTINUE
		IF (ISAMP .LT. NEND1) GO TO 5100
		IF (INTPL .EQ. 0) GO TO 6005
895		IF (ISAMP .GT. NEND1) GO TO 6015
		ISPLIT = ISPLIT + 1
		GO TO 9010
	6015	IF (ISAMP .LT. NSAMP) GO TO 5100
		ISPLIT = ISPLIT + 1
900		IF (ISPLIT .EQ. 3) GO TO 9010
	6005	CONTINUE
		IF (NADJST .EQ. 0) GO TO 7000
		IFAIL = AFAIL(1)
		WRITE (6,1020)
905		WRITE (6,6020) 1,IFAIL
	6020	FORMAT (10X,2I10)
		SUM = 0.0
		DO 6030 I2 = 2, NRDS
		SUM = SUM + AFAIL(I2-1)
910		IFAIL = AFAIL(I2) + SUM
		WRITE (6,6020) I2,IFAIL
	6030	CONTINUE

EXPLANATIONS (CONTINUED)

HORIZONTAL SENSING ERROR STANDARD DEVIATION SIGXS. WHEN NADJST EQUALS 1, ADJX HAS BEEN DETERMINED IN SIMILAR FASHION WITH CONSIDERATION OF POSSIBLY DIFFERENT ERRORS FOR GUNNER AND COMMANDER. MINUS SIGN IS USED WITH ADJX BECAUSE, IF ROUND IS SENSED AS BEING OFF IN ONE DIRECTION (FOR EXAMPLE, RIGHT AND DOWN), FIRING WEAPON IS MOVED IN OPPOSITE DIRECTION (IN THIS EXAMPLE, LEFT AND UP). TERMS IN FORMULA FOR YC1 PARALLEL THOSE IN XC1 FORMULA. FAC NEEDS TO BE RESET SO THAT LAY ERRORS WILL NO LONGER BE TREATED EXPLICITLY SINCE THEY ARE INCLUDED IN SENSING ERRORS.

- 885- 890 WHEN PASSN HAS NONZERO VALUE AND ENGAGEMENT INVOLVES BASIC ADJUSTMENT METHOD, UPDATE Z ARRAY TO ACCOUNT FOR CUMULATIVE PASSENGER PERSONNEL CASUALTIES CAUSED BY ROUNDS FIRED BEFORE MISSING ROUND OF CURRENT CONCERN.
- 891 PROCEED WITH NEXT ROUND UNLESS MAXIMUM NUMBER OF ROUNDS ALLOWED HAVE ALREADY BEEN ACCOUNTED FOR.
- 893- 901 PROCEED WITH NEXT SAMPLE ENGAGEMENT UNLESS ALL ENGAGEMENTS NEEDED AT THIS STAGE OF CALCULATIONS HAVE BEEN COMPLETED.
- 893- 894 SKIP PROGRAM LINES 895 THROUGH 900 IF ISAMP EQUALS NEND1 AND RUN DOES NOT INVOLVE RANGE INTERPOLATION OF VULNERABILITY DATA.
- 895- 897 WHEN ISAMP EQUALS NEND1, RESET ISPLIT TO INDICATE FIRST PART OF ENGAGEMENT SIMULATIONS FOR IC VALUE OF INTEREST AND ASSOCIATED FORWARD OR REVERSE ANGLE HAS BEEN COMPLETED. AFTER BEING RESET, ISPLIT EQUALS 1 FOR FORWARD ANGLE OR 2 FOR REVERSE ANGLE. CONTINUE PROCESSING AT PROGRAM STATEMENT 9010. PROGRAM LINE 895 CAUSES NEXT TWO LINES TO BE SKIPPED WHEN ISAMP EXCEEDS NEND1.
- 898- 900 PROCEED WITH NEXT ENGAGEMENT UNLESS ALL NSAMP ENGAGEMENTS HAVE BEEN COMPLETED. RESET ISPLIT TO 3 FOR FORWARD ANGLE OR 4 FOR REVERSE ANGLE TO INDICATE SECOND PART OF ENGAGEMENT SIMULATIONS FOR IC AND RELATED FORWARD OR REVERSE ANGLE HAS BEEN DONE. CONTINUE AT PROGRAM STATEMENT 9010 IF CALCULATIONS FOR REVERSE ANGLE ARE STILL INCOMPLETE.
- 903- 912 IF FAIL ARRAY CONTAINS CUMULATED VALUES CORRESPONDING TO AFAIL ARRAY. IFAIL(I2) IS NUMBER OF ENGAGEMENTS IN WHICH SECOND FAILURE TO SENSE THAT CAUSED END OF ENGAGEMENT OCCURRED ON ROUND LESS THAN OR EQUAL TO I2. WRITE IFAIL ARRAY QUANTITIES.
- 914 PROGRAM LINES 915 THROUGH 1132 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH AT LEAST ONE OF NDTRM1, NDTRM2, NDTRM3, NDTRM4, AND NDTRM5 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA HAS BEEN INVOLVED.
- 915-1132 THESE STATEMENTS ESSENTIALLY CONSTITUTE COMPUTER ROUTINE (ALTHOUGH STATEMENTS HAVE NOT BEEN STRUCTURED AS SEPARATE ROUTINE IN THIS PROGRAM) FOR PROCESSING HORIZONTAL OR VERTICAL OFFSET DISTANCES BASED ON IMPACT POINTS OF HITTING OR MISSING ROUNDS IN TARGET PLANE. OBJECTIVE OF PROCESSING IS TO ESTIMATE MEAN AND OBTAIN THREE ESTIMATES OF STANDARD DEVIATION FOR NORMAL DISTRIBUTIONS TENTATIVELY ASSUMED TO FIT SUCH OFFSET DATA. AFTER COMPLETION OF COMPUTER RUN, ANALYST CAN STUDY THREE SETS OF PARAMETERS TO JUDGE HOW CLOSELY NORMAL DISTRIBUTION APPLIES AND TO MAKE BEST ESTIMATE FOR PARAMETERS OF INTEREST. PAPER EXPLAINING PROCESSING OF OFFSET DISTANCES WAS PRESENTED AT 1979 ARMY NUMERICAL ANALYSIS AND COMPUTERS CONFERENCE. THIS PAPER (WITH MINOR CHANGES) IS INCLUDED AS APPENDIX B OF THIS REPORT. N EQUALLING 1, 2, OR 3 IS RELATED TO HITTING OR MISSING FIRST ROUNDS AS ALREADY EXPLAINED. PROVISION HAS ALSO BEEN MADE FOR N VALUES OF 4 AND 5 TO BE AVAILABLE FOR POSSIBLE FUTURE USE. CALCULATIONS INVOLVING ANY PARTICULAR N VALUE ARE DONE ONLY IF CONTROL QUANTITY KDMSTC(N) IS NOT 0.
- 1134-1135 PROGRAM LINES 1136 THROUGH 1295 INVOLVE DETERMINISTIC CALCULATIONS OF HIT

PROGRAM LISTING (CONTINUED)

```

7000 CONTINUE
915 IF ( ISPLIT .EQ. 4 ) GO TO 7400
      N = 0
7005 IF ( N .EQ. 5 ) GO TO 7400
      N = N + 1
      IF ( KDMSTC(N) .EQ. 0 ) GO TO 7005
920 DO 7010 I = 1,2
      AVRG = 0.0
      TMINUS = 0.0
      TPLUS = 0.0
      KTIMES = 0
      DO 7020 J = 1,50
925 TERM1 = NMINUS(J,I,N)
      TERM2 = NPLUS(J,I,N)
      TMINUS = TMINUS + TERM1
7020 TPLUS = TPLUS + TERM2
      TOTAL(I) = TMINUS + TPLUS
930 NTOTAL = TOTAL(I)
      T5000 = TOTAL(I) * 0.5
      N5000 = T5000
      IF ( T5000 .NE. TMINUS ) GO TO 7024
      DO 7022 K = 1,50
935 NPOS(K) = NPLUS(K,I,N)
7022 NNEG(K) = NMINUS(K,I,N)
      GO TO 7200
7024 IF ( T5000 .LT. TMINUS ) GO TO 7025
      DIFF = T5000 - TMINUS
940 DO 7030 J = 1,50
      PLUS = NPLUS(J,I,N)
      IF ( PLUS .LT. DIFF ) GO TO 7035
      IFRCTN = 1000.0 * DIFF / PLUS
      FRCTN = FLOAT(IFRCTN) / 1000.0
945 AVRG = AVRG + FRCTN*20.0
      JEND = 100 - KTIMES
      LTIMES = 50 - KTIMES
      LEND = 1 + KTIMES
      DO 7040 K = 1,50
950 NNEG(K) = 0
7040 NPOS(K) = 0
      NCMLTN = 0
      NCMLTP = 0
      L = 0
955 7050 IF ( L .EQ. 100 ) GO TO 7200
      L = L + 1
      LL = L
      IF ( L .LE. 50 ) LL = 51 - L
      M = L
960 IF ( L .GT. 50 ) M = L - 50
      IF ( LL .LE. JEND ) GOTO 7055
      NPOS(M) = 0
      GO TO 7060
965 7055 IF ( LL .LT. JEND ) GOTO 7065
      NTERM = (IFRCTN*NPLUS(50,I,N)+500) / 1000
      NPOS(M) = NPLUS(50,I,N) - NTERM
      NCMLTP = NCMLTP + NPOS(M)
      GO TO 7060
7065 IF ( LL .LE. LTIMES ) GOTO 7075

```

PROGRAM LISTING (CONTINUED)

```

970      IF ( LL .LE. 50 ) GOTO 7070
          NTERM1 = (IFRCTN*NPLUS(L-LTIMES,I,N)+500) / 1000
          NTERM2 = (IFRCTN*NPLUS(L-LTIMES+1,I,N)+500) / 1000
          NPOS(M) = NPLUS(L-LTIMES,I,N) - NTERM1 + NTERM2
          NCMLTP = NCMLTP + NPOS(M)
975      GO TO 7060
7070     NTERM1 = (IFRCTN*NPLUS(LEND-M,I,N)+500) / 1000
          NTERM2 = (IFRCTN*NPLUS(LEND-M+1,I,N)+500) / 1000
          NNEG(M) = NPLUS(LEND-M,I,N) - NTERM1 + NTERM2
          NCMLTN = NCMLTN + NNEG(M)
980     GO TO 7060
7075     IF ( LL .LT. LTIMES ) GOTO 7085
          NTERM1 = (IFRCTN*NMINUS(1,I,N)+500) / 1000
          NTERM2 = (IFRCTN*NPLUS(1,I,N)+500) / 1000
          NNEG(M) = NMINUS(1,I,N) - NTERM1 + NTERM2
985     NCMLTN = NCMLTN + NNEG(M)
          GO TO 7060
7085     IF ( LL .EQ. 1 ) GO TO 7095
          NTERM1 = (IFRCTN*NMINUS(LTIMES-LL+1,I,N)+500) / 1000
          NTERM2 = (IFRCTN*NMINUS(LTIMES-LL,I,N)+500) / 1000
990     NNEG(L-KTIMES+1) = NMINUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
          NCMLTN = NCMLTN + NNEG(L-KTIMES+1)
          GO TO 7060
7095     NNEG(50) = (IFRCTN*NMINUS(49-KTIMES,I,N)+500) / 1000
          NXTRA = KTIMES + 1
995     DO 7100 JXTRA = 1,NXTRA
7100     NNEG(50) = NNEG(50) + NMINUS(49-KTIMES+JXTRA,I,N)
          NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
          NNEG(50) = NNEG(50) + NTERM
          NCMLTN = NCMLTN + NNEG(50)
1000    7060 IF ( NCMLTP .EQ. NTOTAL ) L = 100
          IF ( L .GT. 50 ) GO TO 7050
          IF ( NCMLTN .LT. N5000 ) GO TO 7050
          NCMLTP = NCMLTN
          L = 50
1005    GO TO 7050
7035     DIFF = DIFF - PLUS
          KTIMES = KTIMES + 1
          AVRG = AVRG + 20.0
7030     CONTINUE
1010    7025 DIFF = TMINUS - T5000
          DO 7110 J = 1,50
          AMINUS = NMINUS(J,I,N)
          IF ( AMINUS .LT. DIFF ) GO TO 7115
          IFRCTN = 1000.0 * DIFF / AMINUS
1015     FRCTN = FLOAT(IFRCTN) / 1000.0
          AVRG = AVRG - FRCTN*20.0
          JEND = 100 - KTIMES
          LTIMES = 50 - KTIMES
          LEND = 1 + KTIMES
1020     DO 7120 K = 1,50
          NPOS(K) = 0
7120     NNEG(K) = 0
          NCMLTP = 0
          NCMLTN = 0
1025     L = 0
7130     IF ( L .EQ. 100 ) GO TO 7200

```

PROGRAM LISTING (CONTINUED)

```

      L = L + 1
      LL = L
      IF ( L .LE. 50 ) LL = 51 - L
1030    M = L
      IF ( L .GT. 50 ) M = L - 50
      IF ( LL .LE. JEND ) GOTO 7135
      NNEG(M) = 0
      GO TO 7140
1035 7135 IF ( LL .LT. JEND ) GOTO 7145
      NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
      NNEG(M) = NMINUS(50,I,N) - NTERM
      NCMLTN = NCMLTN + NNEG(M)
      GO TO 7140
1040 7145 IF ( LL .LE. LTIMES ) GOTO 7155
      IF ( LL .LE. 50 ) GOTO 7150
      NTERM1 = (IFRCTN*NMINUS(L-LTIMES,I,N)+500) / 1000
      NTERM2 = (IFRCTN*NMINUS(L-LTIMES+1,I,N)+500) / 1000
      NNEG(M) = NMINUS(L-LTIMES,I,N) - NTERM1 + NTERM2
1045 7150 NCMLTN = NCMLTN + NNEG(M)
      GO TO 7140
      NTERM1 = (IFRCTN*NMINUS(LEND-M,I,N)+500) / 1000
      NTERM2 = (IFRCTN*NMINUS(LEND-M+1,I,N)+500) / 1000
      NPOS(M) = NMINUS(LEND-M,I,N) - NTERM1 + NTERM2
1050 7155 NCMLTP = NCMLTP + NPOS(M)
      GO TO 7140
      IF ( LL .LT. LTIMES ) GOTO 7165
      NTERM1 = (IFRCTN*NPLUS(1,I,N)+500) / 1000
      NTERM2 = (IFRCTN*NMINUS(1,I,N)+500) / 1000
1055 7160 NPOS(M) = NPLUS(1,I,N) - NTERM1 + NTERM2
      NCMLTP = NCMLTP + NPOS(M)
      GO TO 7140
      IF ( LL .EQ. 1 ) GO TO 7175
      NTERM1 = (IFRCTN*NPLUS(LTIMES-LL+1,I,N)+500) / 1000
      NTERM2 = (IFRCTN*NPLUS(LTIMES-LL,I,N)+500) / 1000
1060 7165 NPOS(L-KTIMES+1) = NPLUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
      NCMLTP = NCMLTP + NPOS(L-KTIMES+1)
      GO TO 7140
      NPOS(50) = (IFRCTN*NPLUS(49-KTIMES,I,N)+500) / 1000
      NXTRA = KTIMES + 1
1065 7170 DO 7180 JXTRA = 1,NXTRA
      NPOS(50) = NPOS(50) + NPLUS(49-KTIMES+JXTRA,I,N)
      NTERM = (IFRCTN*NPLUS(50,I,N)+500) / 1000
      NPOS(50) = NPOS(50) + NTERM
      NCMLTP = NCMLTP + NPOS(50)
1070 7140 IF ( NCMLTN .EQ. NTOTAL ) L = 100
      IF ( L .GT. 50 ) GO TO 7130
      IF ( NCMLTP .LT. N5000 ) GO TO 7130
      NCMLTN = NCMLTP
1075 7145 L = 50
      GO TO 7130
      DIFF = DIFF - AMINUS
      KTIMES = KTIMES + 1
      AVRG = AVRG - 20.0
1080 7110 CONTINUE
      7200 CONTINUE
      DO 7310 K = 1,50
      IF ( K .GT. 1 ) GO TO 7315

```

PROGRAM LISTING (CONTINUED)

```

1085      NSUM1 = NPOS(K)
          NSUM2 = NNEG(K)
          GO TO 7320
7315      NSUM1 = NSUM1 + NPOS(K)
          NSUM2 = NSUM2 + NNEG(K)
1090      7320 NCMPOS(K) = NSUM1
          NCMNEG(K) = NSUM2
          NRFLCT(K) = NSUM1 + NSUM2
7310      CONTINUE
          DO 7330 J = 1,50
          SIGMAX = J * 20
1095      IF ( J .GT. 1 ) GO TO 7335
          SMFRQ1 = 0.0
          SMFRQ2 = NRFLCT(1) * 10000 / NTOTAL
          K5 = 5
          K10 = 10
1100      GO TO 7350
7335      SMFRQ1 = SMFRQ2
          IF ( J .EQ. 50 ) GO TO 7345
          SMFRQ2 = NRFLCT(J) * 10000 / NTOTAL
          GO TO 7350
1105      7345 SMFRQ2 = 10000.0
          7350 FRQNCY = SMFRQ2 - SMFRQ1
          IF ( K5 .NE. 5 ) GO TO 7355
          IF ( SMFRQ2 .LT. 3829.2 ) GOTO 7330
          D05 = (SMFRQ2-3829.2) / FRQNCY
1110      SIG05 = (SIGMAX-D05*20.0) / 0.5
          K5 = 0
          7355 IF ( K10 .NE. 10 ) GO TO 7365
          IF ( SMFRQ2 .LT. 6826.8 ) GOTO 7330
          D10 = (SMFRQ2-6826.8) / FRQNCY
1115      SIG10 = SIGMAX - D10*20.0
          K10 = 0
          7365 IF ( SMFRQ2 .LT. 8663.8 ) GOTO 7330
          D15 = (SMFRQ2-8663.8) / FRQNCY
          SIG15 = (SIGMAX-D15*20.0) / 1.5
1120      GO TO 7370
          7330 CONTINUE
          7370 WRITE ( 6,1020 )
          WRITE ( 6,7380) N,I,SIG05,SIG10,SIG15
1125      7380 FORMAT ( 10X,26H N,I,SIG05,SIG10,SIG15 ,2I10,3F10.4 )
          BIASXY(I,N) = AVRG
          IF ( I .EQ. 1 ) SSQRRE = SIGXL**2 + SIGXR**2
          IF ( I .EQ. 2 ) SSQRRE = SIGYL**2 + SIGYR**2
          SIGMXY(1,I,N) = SQRT(SIG05**2+SSQRRE)
          SIGMXY(2,I,N) = SQRT(SIG10**2+SSQRRE)
1130      SIGMXY(3,I,N) = SQRT(SIG15**2+SSQRRE)
          7010 CONTINUE
          GO TO 7005
          7400 CONTINUE
          IF ( NSMDTR .EQ. 0 .AND. NHTKLL .EQ. 0 ) GOTO 8000
1135      IF ( ISPLIT .EQ. 4 .AND. NHTKLL .EQ. 0 ) GO TO 8000
          NCLLS1 = 99999
          NCLLS2 = 99999
          IF ( NSMDTR .EQ. 0 ) GO TO 7405
          IF ( ISPLIT .EQ. 4 ) GO TO 7405
1140      NCLLS1 = 0

```

PROGRAM LISTING (CONTINUED)

```

DO 7410 N = 1,5
BX(N) = BIASXY(1,N)
BY(N) = BIASXY(2,N)
DO 7410 K = 1,3
1145 PH(K,N) = 0.0
      SIGX(K,N) = SIGMXY(K,1,N)
      SIGY(K,N) = SIGMXY(K,2,N)
DO 7410 L = 1,4
      PKILL(L,K,N) = 0.0
1150      7410 CONTINUE
      7405 IF ( NHTKLL .EQ. 0 ) GO TO 7415
      NCLLS2 = 0
DO 7420 N = 1,5
      PPH(N) = 0.0
1155 IF ( N .EQ. 5 ) PPH(N) = 1.0
DO 7420 L = 1,4
      PKSHOT(L,N) = 0.0
      PPKHIT(L,N) = 0.0
      7420 CONTINUE
1160      7415 DO 7430 J = 1,NY
      IF ( AY(J)+H .LE. YBASE ) GO TO 7430
      Y2 = AY(J) + H - YC
      Y1 = AY(J) - H - YC
      IF ( Y1 .LT. YBASE-YC ) Y1 = YBASE - YC
1165 DO 7440 I = 1,NX
      K22 = IK(J,I)
      IF ( K22 .LE. 0 ) GO TO 7440
      X2 = AX(I) + H - XC
      X1 = AX(I) - H - XC
1170 IF ( NPRHIT .EQ. 1 ) GO TO 7445
      N = -49
DO 7450 L = 1,4
      IF ( NBETA .EQ. NANGLE ) GO TO 7452
      IST = SHIFT(MPK(K22,IA),N) .AND. MASK11
      ST = IST
1175 PK(L) = 0.001 * ST
      GO TO 7450
      7452 IST1 = SHIFT(MPK(K22,IB),N) .AND. MASK11
      ST1 = IST1
1180 PK(L+5) = 0.001 * ST1
      7450 N = N + 11
      7445 IF ( NSMDTR .EQ. 0 ) GO TO 7475
      IF ( ISPLIT .EQ. 4 ) GO TO 7475
      N = 0
1185      7455 IF ( N .EQ. 5 ) GO TO 7475
      N = N + 1
      IF ( KDMSTC(N) .EQ. 0 ) GO TO 7455
DO 7460 K = 1,3
      QOFZ1 = CNORM((X2-BX(N))/SIGX(K,N))
      QOFZ2 = CNORM((X1-BX(N))/SIGX(K,N))
      QOFZ3 = CNORM((Y2-BY(N))/SIGY(K,N))
      QOFZ4 = CNORM((Y1-BY(N))/SIGY(K,N))
      POFXY = (QOFZ1-QOFZ2) * (QOFZ3-QOFZ4)
      PH(K,N) = PH(K,N) + POFXY
1190      IF ( NPRHIT .EQ. 1 ) GO TO 7460
DO 7470 L = 1,4
      PKCELL = PK(L)

```


EXPLANATIONS (CONTINUED)

PROBABILITIES AND KILL PROBABILITIES. LINES NEED TO BE SKIPPED WHEN NSMDTR AND NHTKLL CONTROLS ARE BOTH 0. CONDITION INVOLVING ISPLIT EQUALLING 4 CAUSES LINES TO BE SKIPPED ONLY FOR RANGES REQUIRING INTERPOLATION OF VULNERABILITY DATA IF NSMDTR IS NOT 0.

1136-1137 INITIAL SETTINGS.

1138-1139 PROGRAM LINES 1140 THROUGH 1150 CAN BE INVOLVED ONLY IF NSMDTR EXCEEDS 0 AND RANGE OF CONCERN DOES NOT REQUIRE INTERPOLATION OF VULNERABILITY DATA.

1140 NEW INITIAL SETTING OVERRIDING 99999.

1141-1150 INITIAL SETTINGS.

1151 PROGRAM LINES 1152 THROUGH 1159 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.

1152 NEW INITIAL SETTING OVERRIDING 99999.

1153-1159 INITIAL SETTINGS.

1160-1227 CONSIDER IN TURN EACH HORIZONTAL STRIP OF CELLS IN SMALLEST RECTANGLE ENCLOSING TARGET.

1161-1164 DETERMINE Y COORDINATES Y1 AND Y2 CORRESPONDING TO LOWER AND UPPER EDGES RESPECTIVELY OF PARTICULAR STRIP. AY(J) REPRESENTS Y COORDINATE OF HORIZONTAL CENTERLINE OF STRIP. IGNORE STRIP IF ITS CENTERLINE IS BELOW BASE OF TARGET. IF NECESSARY, RESET Y1 TO MAKE IT CORRESPOND TO TARGET BASE.

1165-1226 CONSIDER IN TURN EACH CELL IN PARTICULAR HORIZONTAL STRIP.

1166-1167 K22 IS USED FOR TEMPORARY STORAGE OF IK(J,I) VALUE ASSOCIATED WITH PARTICULAR CELL. IGNORE CELL WHEN K22 EQUALLING 0 INDICATES CELL IS NOT PART OF TARGET.

1168-1169 DETERMINE X COORDINATES X1 AND X2 CORRESPONDING RESPECTIVELY TO LEFT AND RIGHT EDGES OF TARGET CELL.

1170 SKIP PROGRAM LINES 1171 THROUGH 1181 IF ONLY HIT PROBABILITIES ARE INVOLVED.

1171-1181 UNPACK MPK ARRAY QUANTITY THAT CORRESPONDS TO TARGET CELL HIT AND ASSOCIATED TARGET ORIENTATION TO RETRIEVE PROBABILITIES OF M KILL, F KILL, M OR F KILL, AND K KILL PER HIT. STORE THESE IN PK ARRAY. THESE PROGRAM LINES ARE ESSENTIALLY LIKE LINES 753 THROUGH 763. EXCEPT FOR EXPECTED CASUALTIES NOT BEING OF CONCERN HERE, EXPLANATIONS FOR LINES 753 THROUGH 772 APPLY.

1182-1183 SKIP PROGRAM LINES 1184 THROUGH 1203 IF NSMDTR IS 0 OR IF RANGE OF CONCERN INVOLVES INTERPOLATION OF VULNERABILITY DATA.

1184-1187 PROCESSING INDICATED BY PROGRAM LINES 1188 THROUGH 1203 IS DONE OR SKIPPED FOR N EQUALLING 1, 2, 3, 4, OR 5 ACCORDING TO WHETHER KDMSTC(N) EXCEEDS OR EQUALS 0.

1188-1201 K CORRESPONDS TO THREE ALTERNATIVE SETS OF STANDARD DEVIATIONS ESTIMATED FOR HORIZONTAL AND VERTICAL OFFSET DISTANCE DATA FROM SIMULATED ENGAGEMENTS.

1189-1194 QOFZ1 IS PROBABILITY THAT PARTICULAR PAIR OF BIAS AND STANDARD DEVIATION VALUES RESULTS IN X COORDINATE OF PROJECTILE IMPACT POINT NOT EXCEEDING X COORDINATE OF RIGHT EDGE OF CELL BEING CONSIDERED. QOFZ2 IS PROBABILITY X COORDINATE OF IMPACT POINT DOES NOT EXCEED THAT OF LEFT EDGE OF CELL. DIFFERENCE QOFZ1-QOFZ2 EQUALS PROBABILITY THAT IMPACT POINT LIES ON VERTICAL LINE THROUGH SOME CELL POINT. SIMILARLY, DIFFERENCE QOFZ3-QOFZ4 EQUALS PROBABILITY THAT IMPACT POINT LIES ON HORIZONTAL LINE THROUGH SOME CELL

PROGRAM LISTING (CONTINUED)

```

1200      7470  IF ( NBETA .EQ. NANGLE ) PKCELL = PK(L+5)
           7460  PKILL(L,K,N) = PKILL(L,K,N) + POFXY*PKCELL
           CONTINUE
           7460  CONTINUE
           NCLLS1 = NCLLS1 + 1
           GO TO 7455
           7475  IF ( NHTKLL .EQ. 0 ) GO TO 7440
1205      DO 7480 N = 1,5
           IF ( N .EQ. 5 ) GO TO 7485
           IF ( SSIGX(N) .EQ. 0.0 .OR. SSIGY(N) .EQ. 0.0 ) GO TO 7480
           QQOFZ1 = CNORM((X2-BBX(N))/SSIGX(N))
           QQOFZ2 = CNORM((X1-BBX(N))/SSIGX(N))
1210      QQOFZ3 = CNORM((Y2-BBY(N))/SSIGY(N))
           QQOFZ4 = CNORM((Y1-BBY(N))/SSIGY(N))
           PPOFXY = (QQOFZ1-QQOFZ2) * (QQOFZ3-QQOFZ4)
           PPH(N) = PPH(N) + PPOFXY
           GO TO 7490
1215      7485  IF ( NRDTYP .EQ. 0 .AND. NRANGE .GT. 1 ) GO TO 7480
           PPOFXY = 1.0
           PPH(5) = PPH(5) + PPOFXY
           7490  NCLLS2 = NCLLS2 + 1
           IF ( NPRHIT .EQ. 1 ) GO TO 7480
1220      DO 7510 L = 1,4
           PPCELL = PK(L)
           IF ( NBETA .EQ. NANGLE ) PPCELL = PK(L+5)
           PKSHOT(L,N) = PKSHOT(L,N) + PPOFXY*PPCELL
           7510  CONTINUE
1225      7480  CONTINUE
           7440  CONTINUE
           7430  CONTINUE
           IF ( NHTKLL .EQ. 0 ) GO TO 7600
           IF ( NPRHIT .EQ. 1 ) GO TO 7600
1230      DO 7530 L = 1,4
           DO 7540 N = 1,5
           IF ( PPH(N) .GT. 0.000001 ) PPKHIT(L,N) = PKSHOT(L,N) / PPH(N)
           7540  CONTINUE
           7530  CONTINUE
1235      7600  CONTINUE
           IF ( NSMDTR .EQ. 0 ) GOTO 7700
           IF ( ISPLIT .EQ. 4 ) GO TO 7700
           WRITE ( 6,1020 )
1240      7610  WRITE ( 6,7610 ) ( BX(I),I=1,5 )
           FORMAT ( 10X,11H BX(5) ,10X,5F10.4 )
           WRITE ( 6,7620 ) ( BY(I),I=1,5 )
           7620  FORMAT ( 10X,11H BY(5) ,10X,5F10.4 )
           DO 7630 I = 1,3
           WRITE ( 6,1020 )
1245      7640  WRITE ( 6,7640 ) ( SIGX(I,J),J=1,5 )
           FORMAT ( 10X,11H SIGX(3,5) ,10X,5F10.4 )
           WRITE ( 6,7650 ) ( SIGY(I,J),J=1,5 )
           7650  FORMAT ( 10X,11H SIGY(3,5) ,10X,5F10.4 )
           WRITE ( 6,7660 ) ( PH(I,J),J=1,5 )
1250      7660  FORMAT ( 10X,21H PH(3,5) ,5F10.4 )
           7630  CONTINUE
           IF ( NPRHIT .EQ. 1 ) GOTO 7700
           DO 7670 J = 1,3
           WRITE ( 6,1020 )

```

EXPLANATIONS (CONTINUED)

POINT. PRODUCT POFXY OF TWO DIFFERENCES IS PROBABILITY OF HITTING CELL. EACH PH(K,N) VALUE IS CUMULATIVE HIT PROBABILITY FOR ALL CELLS ALREADY PROCESSED AND EVENTUALLY APPLIES TO ENTIRE TARGET.

- 1195 SKIP PROGRAM LINES 1196 THROUGH 1200 IF ONLY HIT PROBABILITIES ARE INVOLVED.
- 1196-1200 L CORRESPONDS TO FOUR KILL CRITERIA CONSIDERED IN TURN. PKCELL IS USED FOR TEMPORARY STORAGE OF PK(L) OR PK(L+5). THESE TWO VALUES APPLY TO FORWARD OR REVERSE ANGLE RESPECTIVELY. PRODUCT OF POFXY AND PKCELL IS PROBABILITY OF HITTING PARTICULAR CELL AND THEREBY KILLING TARGET. EACH PKILL(L,K,N) VALUE IS CUMULATIVE PROBABILITY ACCOUNTING FOR ALL CELLS ALREADY PROCESSED AND EVENTUALLY EQUALS PROBABILITY OF HIT AND KILL FOR ENTIRE TARGET.
- 1202 NCLLS1 IS UPDATED AND EVENTUALLY EQUALS PRODUCT OF 1) TOTAL NUMBER OF TARGET CELLS AND 2) NUMBER OF NONZERO QUANTITIES IN SET KDMSTC(1), KDMSTC(2), KDMSTC(3), AND KDMSTC(4).
- 1203 PROCESSING HAS BEEN COMPLETED FOR PARTICULAR VALUE OF N AND MAY NEED TO BE REPEATED FOR SOME OTHER VALUE.
- 1204 PROGRAM LINES 1205 THROUGH 1225 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.
- 1205-1225 N EQUALS 1 FOR FIRST ROUNDS, 2 FOR ROUNDS IMMEDIATELY FOLLOWING ROUND THAT HITS TARGET, 3 FOR ROUNDS IMMEDIATELY FOLLOWING SENSED MISS, 4 FOR ROUNDS IMMEDIATELY AFTER MISS THAT IS NOT SENSED, AND 5 FOR HITTING ROUNDS WHOSE IMPACT POINTS ARE CONSIDERED SPREAD UNIFORMLY AT RANDOM OVER VERTICAL TARGET AREA. CALCULATE HIT PROBABILITIES AND PROBABILITIES OF HITTING AND KILLING TARGET FOR N EQUALLING 1 THROUGH 4 AND KILL PROBABILITY OF RANDOM HIT FOR N EQUALLING 5.
- 1206-1207 CALCULATIONS CORRESPONDING TO PROGRAM LINES 1208 THROUGH 1214 ARE NOT APPLICABLE FOR N EQUALLING 5. FOR N EQUAL TO 1 THROUGH 4, PROCESSING INDICATED BY LINES 1208 THROUGH 1224 IS DONE WHEN NONZERO STANDARD DEVIATION INPUTS HAVE BEEN PREVIOUSLY ESTABLISHED OR IS OTHERWISE SKIPPED.
- 1208-1214 SIMILAR TO PROGRAM LINES 1189 THROUGH 1194. EACH PPH(N) VALUE IS CUMULATIVE HIT PROBABILITY FOR ALL CELLS ALREADY PROCESSED AND EVENTUALLY APPLIES TO ENTIRE TARGET. CONTINUE AT PROGRAM STATEMENT 2490.
- 1215 FOR NRDTYP EQUALLING 0, SKIP PROGRAM LINES 1216 THROUGH 1224 WHEN ASSOCIATED CALCULATIONS HAVE ALREADY BEEN DONE FOR FIRST RANGE. PROCESSING INVOLVED IS REPEATED FOR ALL OTHER RANGES WHEN TARGET VULNERABILITY DATA CAN VARY WITH RANGE.
- 1216-1217 FOR N EQUALLING 5, PROBABILITY OF HITTING EACH CELL IS NOT INVOLVED IN SAME WAY AS FOR OTHER N VALUES AND IS SET TO 1. THIS SPECIAL SETTING CAUSES PPH(5) TO BECOME CELL COUNTER.
- 1218 NCLLS2 IS UPDATED AND EVENTUALLY EQUALS PRODUCT OF 1) TOTAL NUMBER OF TARGET CELLS AND 2) NUMBER OF SETS OF NONZERO HORIZONTAL AND VERTICAL STANDARD DEVIATIONS USED FOR HIT PROBABILITY CALCULATIONS PLUS 1 IF SETTING OF PPOFXY TO 1.0 AND PROGRAM LINES 1220 THROUGH 1224 ARE NOT SKIPPED FOR N EQUAL TO 5.
- 1219 SKIP PROGRAM LINES 1220 THROUGH 1224 IF ONLY HIT PROBABILITIES ARE INVOLVED.
- 1220-1224 SIMILAR TO PROGRAM LINES 1196 THROUGH 1200. FOR N EQUALLING 1 THROUGH 4, EACH PKSHOT(L,N) VALUE IS CUMULATIVE PROBABILITY ACCOUNTING FOR ALL CELLS ALREADY PROCESSED AND EVENTUALLY EQUALS PROBABILITY OF HIT AND KILL FOR ENTIRE TARGET. PKSHOT(L,5) VALUES ARE SIMILAR BUT DO NOT REPRESENT PROBABILITIES.
- 1228 PROGRAM LINES 1230 THROUGH 1234 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.

EXPLANATIONS (CONTINUED)

- 1229 SKIP PROGRAM LINES 1230 THROUGH 1234 IF ONLY HIT PROBABILITIES ARE INVOLVED.
- 1230-1234 DIVIDE PKSHOT(L,N) VALUES BY PPH(N) TO OBTAIN KILL PROBABILITIES PER HIT ON TARGET. FOR N EQUALLING 5, DIVISOR IS TOTAL NUMBER OF TARGET CELLS BECAUSE UNITY CHANCE OF HIT HAS BEEN PREVIOUSLY USED FOR EACH CELL.
- 1236-1237 PROGRAM LINES 1238 THROUGH 1258 CAN BE INVOLVED ONLY IF NSMDTR EXCEEDS 0 AND RANGE OF CONCERN DOES NOT REQUIRE INTERPOLATION OF VULNERABILITY DATA.
- 1238-1258 WRITE OUTPUT.
- 1260 PROGRAM LINES 1261 THROUGH 1292 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.
- 1261-1292 WRITE OUTPUT.
- 1261-1263 SPECIAL TITLING INVOLVING IC AND MSET APPLIES ONLY FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.
- 1275-1278 FOR MOVING TARGET OR MOVING FIRING WEAPON RUN, WRITE FIRST ROUND HIT PROBABILITY ONLY AFTER ADJUSTING TO ACCOUNT FOR RELIABILITY FACTOR RELT.
- 1280 SKIP PROGRAM LINES 1281 THROUGH 1292 IF ONLY HIT PROBABILITIES ARE INVOLVED.
- 1285-1288 FOR MOVING TARGET OR MOVING FIRING WEAPON RUN, WRITE KILL PROBABILITIES PER SHOT ONLY AFTER ADJUSTING TO ACCOUNT FOR RELIABILITY FACTORS RELT AND RELF.
- 1294-1295 WRITE NCLLS1 AND NCLLS2 FOR POSSIBLE USE IN CHECKING OUTPUT. EITHER QUANTITY STILL EQUALLING 99999 INDICATES ASSOCIATED CALCULATIONS WERE SKIPPED.
- 1297-1358 IF SIMULATED ENGAGEMENTS ARE INVOLVED IN RUN AND HAVE BEEN COMPLETED FOR BOTH TARGET ORIENTATION ANGLES OF CONCERN, PROCESS DATA IN Z AND AKIL ARRAYS AND PRINT OUTPUT.
- 1299-1315 CALCULATE AVERAGE VALUES PER SAMPLE ENGAGEMENT FOR EACH QUANTITY IN Z ARRAY. AVERAGE $Z(I2,I)$ VALUES PER ENGAGEMENT FOR I EQUALLING 1 THROUGH 10 CAN BE INTERPRETED AS CORRESPONDING PROBABILITIES OF HITTING OR KILLING TARGET. PERSONNEL CASUALTIES ASSOCIATED WITH I EQUALLING 11 AND 12 REPRESENT AVERAGE EXPECTED CASUALTIES APPLICABLE TO TARGET VEHICLE PASSENGERS.
- 1317-1344 IF RUN INVOLVES SUBSEQUENT ROUNDS AS WELL AS FIRST ROUNDS AND BASIC FIRE ADJUSTMENT PROCEDURE FOR MISSING ROUNDS, CALCULATE AND PRINT AVERAGE NUMBERS OF ROUNDS NEEDED TO HIT TARGET AND TO ACHIEVE TARGET KILL ACCORDING TO VARIOUS CRITERIA CONSIDERED.
- 1322-1344 ACHIEVEMENT OF FIRST HIT AND KILLING OF TARGET ACCORDING TO VARIOUS CRITERIA ARE CONSIDERED FOR RELATED FORWARD AND REVERSE ORIENTATION ANGLES.
- 1323-1325 CONSIDER ONLY FIRST HIT ON TARGET WHEN NPRHIT EQUALS 1.
- 1327-1328 INITIAL SETTINGS.
- 1329-1340 AVERAGE (OR EXPECTED) NUMBER OF ROUNDS NEEDED FOR TARGET HIT OR TARGET KILL CAN BE OBTAINED BY ADDING ALL PRODUCTS OF 1) SPECIFIC NUMBER OF ROUNDS AND 2) CORRESPONDING FRACTION OF ALL ENGAGEMENTS FOR WHICH EXACTLY THAT NUMBER OF ROUNDS ARE REQUIRED TO HIT OR KILL TARGET. ONLY FIRST NRDS ROUNDS ARE PROCESSED EXPLICITLY IN THIS FASHION. APPROXIMATE EXTRAPOLATION FORMULA IS APPLIED AS NECESSARY TO ACCOUNT FOR ALL OTHER ROUNDS.
- 1329-1332 FOR I EQUAL TO 2, $SMIK = SMIK + 2(Z(2,K) - Z(1,K))$. TERM SMIK APPEARING TO RIGHT OF EQUAL SIGN IN THIS EQUATION IS EQUIVALENT TO $1(Z(1,K))$. SINCE $Z(2,K)$ IS

PROGRAM LISTING (CONTINUED)

```

1255      DO 7670 I = 1,4
          WRITE ( 6,7680 ) ( PKILL(I,J,K),K=1,5 )
          7680 FORMAT ( 10X,21H PKILL(4,3,5) ,5F10.4 )
          7670 CONTINUE
          7700 CONTINUE
1260      IF ( NHTKLL .EQ. 0 ) GO TO 7800
          IF ( ISTMOV .NE. 1 ) GO TO 7705
          WRITE ( 6,7702 ) IC,MSET
          7702 FORMAT ( / /, 20X,6H IC = ,I3,10X,8H MSET = ,I3 )
          7705 WRITE ( 6,1020 )
1265      WRITE ( 6,7710 ) (BBX(I),I=1,4 )
          7710 FORMAT ( 10X,11H BBX(4) ,10X,4F10.4 )
          WRITE ( 6,7720 ) (BBY(I),I=1,4 )
          7720 FORMAT ( 10X,11H BBY(4) ,10X,4F10.4 )
          WRITE ( 6,7730 ) (SSIGX(I),I=1,4 )
1270      7730 FORMAT ( 10X,11H SSIGX(4) ,10X,4F10.4 )
          WRITE ( 6,7740 ) (SSIGY(I),I=1,4 )
          7740 FORMAT ( 10X,11H SSIGY(4) ,10X,4F10.4 )
          WRITE ( 6,7750 ) (PPH(I),I=1,5 )
          7750 FORMAT ( 10X,21H PPH(5) ,5F10.4 )
1275      IF ( ISTMOV .NE. 1 ) GO TO 7755
          PPH(1) = PPH(1) * RELT
          WRITE ( 6,7753 ) (PPH(I),I=1,5 )
          7753 FORMAT ( 10X,21H PPH(5) ,20X,5F10.4 )
          7755 CONTINUE
1280      IF ( NPRHIT .EQ. 1 ) GO TO 7800
          DO 7760 I = 1,4
          PKSHOT(I,5) = 0.0
          WRITE ( 6,7770 ) (PKSHOT(I,J),J=1,5 )
          7770 FORMAT ( 10X,21H PKSHOT(4,5) ,5F10.4 )
1285      IF ( ISTMOV .NE. 1 ) GO TO 7775
          PKSHOT(I,1) = PKSHOT(I,1) * RELT * RELF
          WRITE ( 6,7773 ) (PKSHOT(I,J),J=1,5 )
          7773 FORMAT ( 10X,21H PKSHOT(4,5) ,20X,5F10.4 )
          7775 CONTINUE
1290      WRITE ( 6,7780 ) (PPKHIT(I,J),J=1,5 )
          7780 FORMAT ( 10X,21H PPKHIT(4,5) ,5F10.4 )
          7760 CONTINUE
          7800 WRITE ( 6,1020 )
          WRITE ( 6,7810 ) NCLLS1,NCLLS2
1295      7810 FORMAT ( 10X,18H NCLLS1, NCLLS2 = ,2I10 )
          8000 CONTINUE
          IF ( NHTKLL .EQ. 9 ) GO TO 9000
          IF ( NBETA .LT. NANGLE ) GO TO 9000
          WRITE ( 6,8110 )
1300      8110 FORMAT ( / /, 11X,28H NRDS PROB. (EXP. CAS.), / )
          DO 8120 I = 1,12
          IF ( I .GT. 10 .AND. PASSN .EQ. 0.0 ) GO TO 8125
          DO 8120 I2 = 1,NRDS
          8120 Z(I2,I) = Z(I2,I) / SAMP
1305      8125 CONTINUE
          DO 8130 N = 1,3
          IF ( N .EQ. 3 .AND. PASSN .EQ. 0.0 ) GO TO 8200
          WRITE ( 6,1020 )
          IL = 5*N - 4
1310      IR = IL + 4
          IF ( N .EQ. 3 ) IR = 12

```


PROGRAM LISTING (CONTINUED)

```

DO 8130 I2 = 1, NRDS
WRITE ( 6, 8140 ) I2, (Z(I2, I), I=IL, IR)
1315      8140 FORMAT ( 11X, I4, 9F13.7 )
      8130 CONTINUE
      8200 CONTINUE
IF ( NRD1 .EQ. 1 ) GO TO 9000
IF ( NADJST .GT. 0 ) GO TO 8400
WRITE ( 6, 8310 )
1320      8310 FORMAT ( / /, 31X, 17H AVG. NO. OF RDS., / )
      WRITE ( 6, 1020 )
      DO 8320 K = 1, 10
      IF ( NPRHIT .EQ. 0 ) GO TO 8325
      IF ( K .EQ. 5 .OR. K .EQ. 10 ) GO TO 8325
1325      GO TO 8320
      8325 CONTINUE
      SMIK = Z(1, K)
      AUL = 2.0
      DO 8330 I = 2, NRDS
      SMIK = SMIK + AUL*(Z(I, K)-Z(I-1, K))
1330      8330 AUL = AUL + 1.0
      IF ( Z(NRDS, K) .LE. 0.9999 ) GO TO 8335
      AV = SMIK
      GO TO 8340
1335      8335 AR = 5.0 - (Z(NRDS-5, K)+Z(NRDS-4, K)+Z(NRDS-3, K)+Z(NRDS-2, K)
      A      +Z(NRDS-1, K))
      XX = Z(NRDS, K) - Z(NRDS-5, K)
      IF ( XX .LE. 0.0 ) GO TO 8335
      AZ = AR / XX
      AV = SMIK + (AZ+RDS)*(1.0-Z(NRDS, K))
1340      8340 IF ( AV .GT. 999.0 ) AV = 999.0
      WRITE ( 6, 8350 ) K, AV
      8350 FORMAT ( 20X, I5, 10X, F7.2 )
      8320 CONTINUE
1345      8400 CONTINUE
      WRITE ( 6, 8402 )
      8402 FORMAT ( / /, 22X, 24H PROBABILITY VERSUS TIME, / )
      DO 8410 J = 1, 10
      IF ( NPRHIT .EQ. 0 ) GO TO 8415
1350      IF ( J .EQ. 5 .OR. J .EQ. 10 ) GO TO 8415
      GO TO 8410
      8415 WRITE ( 6, 1020 )
      DO 8420 K = 1, 61
      8420 AKIL(K, J) = AKIL(K, J) / SAMP
1355      WRITE ( 6, 8430 ) ( AKIL(K, J), K=1, 61 )
      8430 FORMAT ( 11X, 10F8.5 )
      8410 CONTINUE
      WRITE ( 6, 1010 )
      9000 CONTINUE
1360      IF ( ISTMOV .EQ. 1 ) GO TO 9305
      9010 IF ( ISPLIT .EQ. 4 ) ISPLIT = 0
      IF ( ISPLIT .NE. 2 ) GO TO 9100
      NANGLE = NANGLE - 1
      IF ( NRRANGE .EQ. 1 ) NEJECT = 1
1365      GO TO 3000
      9100 CONTINUE
      IF ( NSTCRD .GT. 0 ) GO TO 9302
      NANGLE = NANGLE + 1

```

EXPLANATIONS (CONTINUED)

FRACTION OF ALL ENGAGEMENTS IN WHICH TARGET WAS HIT OR KILLED BY FIRST OR SECOND ROUND, DIFFERENCE $Z(2,K)-Z(1,K)$ REPRESENTS FRACTION OF ALL ENGAGEMENTS IN WHICH ACHIEVING HIT OR KILL REQUIRED EXACTLY TWO ROUNDS. FOR I EQUAL TO 3, $SMIK$ EQUALS ITS PREVIOUS VALUE PLUS TERM $3(Z(3,K)-Z(2,K))$. EVENTUALLY $SMIK$ ACCOUNTS FOR ALL OF FIRST NRDS ROUNDS. FURTHER CALCULATING IS UNNEEDED IF $Z(NRDS,K)$ IS EQUAL TO 1 OR VERY NEARLY SO, INDICATING THAT NRDS OR FEWER ROUNDS SUFFICED IN ALL OR PRACTICALLY ALL SAMPLE ENGAGEMENTS. IN THAT CASE AVERAGE NUMBER OF ROUNDS AV EQUALS $SMIK$.

- 1333-1340 APPLY APPROXIMATE AND RATHER INTRICATE EXTRAPOLATION FORMULA TO ACCOUNT FOR ENGAGEMENTS WHERE NRDS OR FEWER ROUNDS DID NOT SUFFICE TO HIT OR KILL TARGET. FORMULA IS BASED ON CONDITIONAL PROBABILITIES OF HIT OR CONDITIONAL PROBABILITIES OF KILL. SUCH CONDITIONAL PROBABILITIES HAVE NOT BEEN INVOLVED SO FAR IN PROGRAM CALCULATIONS BUT ARE INFERRABLE FROM PROBABILITIES IN Z ARRAY. IF NRDS IS NOT TOO SMALL, CONDITIONAL PROBABILITIES FOR EACH ROUND FOLLOWING FIRST NRDS ROUNDS CAN BE CONSIDERED APPROXIMATELY EQUAL TO AVERAGE OF FIVE CONDITIONAL PROBABILITIES APPLYING TO LAST FIVE OF FIRST NRDS ROUNDS. LOWER BOUND OF 10 FOR NRDS HAS BEEN CHOSEN AS ACCEPTABLE IN THIS CONTEXT. AZ REPRESENTS AVERAGE NUMBER OF ROUNDS NEEDED IN ADDITION TO FIRST NRDS ROUNDS WHEN NRDS ROUNDS ARE INSUFFICIENT. CORRESPONDING FRACTION OF ENGAGEMENTS IS INDICATED BY DIFFERENCE $1.0-Z(NRDS,K)$. AVERAGE NUMBER OF ROUNDS AV IS OBTAINED BY ADDING $SMIK$ VALUE ASSOCIATED WITH ENGAGEMENTS WHERE NRDS ROUNDS SUFFICE AND PRODUCT ACCOUNTING FOR ALL OTHER ENGAGEMENTS.
- 1341 PRIMARILY TO AVOID HAVING TO PRINT VERY LARGE NUMBERS, REPLACE ANY NUMBER LARGER THAN 999 BY THIS LIMIT. THERE IS OF COURSE NO PRACTICAL INTEREST IN MANY AVERAGE NUMBERS OF ROUNDS THAT ARE MUCH SMALLER THAN 999 BUT STILL TOO LARGE TO CORRESPOND TO REALISTIC COMBAT ENGAGEMENT SITUATIONS.
- 1346-1357 CALCULATE AVERAGE VALUES PER SAMPLE ENGAGEMENT FOR EACH QUANTITY IN $AKIL$ ARRAY. CONSIDER ONLY FIRST HIT ON TARGET WHEN $NPRHIT$ EQUALS 1. RESULTING AVERAGE $AKIL(K,J)$ VALUES CAN BE INTERPRETED AS CORRESPONDING PROBABILITIES OF HITTING OR KILLING TARGET BEFORE $2(K-1)$ SECONDS.
- 1360 SKIP PROGRAM LINES 1361 THROUGH 1369 FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.
- 1361 SINCE CALCULATIONS INVOLVING RANGE INTERPOLATION OF TARGET VULNERABILITY DATA HAVE BEEN COMPLETED, RESET $ISPLIT$ TO INITIAL SETTING.
- 1362-1365 PROGRAM LINES 1363 THROUGH 1365 APPLY ONLY IF $ISPLIT$ IS 2. CALCULATIONS FOR FIRST PART OF SIMULATIONS HAVE JUST BEEN COMPLETED FOR REVERSE ANGLE OF CONCERN AND $NANGLE$ NEEDS TO BE RESET BEFORE SECOND PART OF SIMULATIONS FOR CORRESPONDING FORWARD ANGLE. $NEJECT$ IS ASSOCIATED WITH LINE SKIPPING OCCASIONALLY NEEDED WHEN TARGET VULNERABILITY DATA ARE READ FROM TAPE OR DISC. CONTINUE AT PROGRAM STATEMENT 3000.
- 1367 SKIP PROGRAM LINES 1368 THROUGH 1370 IF RUN INVOLVES TARGET SHAPE DATA FROM CARDS.
- 1368-1370 CONTINUE EITHER AT PROGRAM STATEMENT 4020 FOR NEXT VALUE OF $NANGLE$ IF ANY OR AT STATEMENT 9310.
- 1371-1374 IF RUN INVOLVES TARGET SHAPE DATA FROM CARDS, CONTINUE AT PROGRAM STATEMENT 4210 FOR NEXT $INTRGTC$ VALUE OF CONCERN OR AT STATEMENT 9310.
- 1375-1379 APPLICABLE FOR MOVING TARGET OR MOVING FIRING WEAPON RUN ONLY. $MSET$ EQUALS 1 THROUGH 6 FOR VARIOUS TARGET SPEED AND EVASIVE MANEUVERING CONDITIONS. $NANGLE$ VALUES FOR MOVING TARGET OR MOVING FIRING WEAPON RUN ARE RESTRICTED TO 1 FOR 0 DEGREES, 3 FOR 30 DEGREES, AND 5 FOR 60 DEGREES. CONTINUE AT PROGRAM STATEMENT 4035 IF ALL SIX $MSET$ VALUES HAVE BEEN CONSIDERED.

PROGRAM LISTING (CONTINUED)

```

1370      IF ( NANGLE .LE. 8 ) GO TO 4020
          GO TO 9310
          9302 NTRGTC = NTRGTC + 1
              IF ( NTRGTC .GT. 4 ) GO TO 9310
              IF ( KTRGTC(NTRGTC) .GT. 0 ) GO TO 4210
              GO TO 9310
1375      9305 MSET = MSET + 1
              IF ( MSET .LE. 6 ) GO TO 4035
              MSET = 1
              NANGLE = NANGLE + 2
              IF ( NANGLE .LE. 5 ) GO TO 4020
1380      9310 NRANGE = NRANGE + 1
              IF ( NRDTYP .EQ. 1 .AND. NEJECT .EQ. 0 ) NEJECT = 1
              IF ( NRANGE .LE. NCASES ) GO TO 2010
          9900 CONTINUE
              CALL EXIT
1385      END

```

```

1      SUBROUTINE NRAN(R1,R2)
          A = SQRT(-2.0*ALOG(RANF(X)))
          B = 6.28318530718 * RANF(X)
          R1 = A * SIN(B)
5      R2 = A * COS(B)
          RETURN
          END

```

```

1      FUNCTION CNORM(X)
          F = 0.0
          AX = ABS(X)
          IF ( AX .GE. 5.0 ) GO TO 10
          F = (((((0.5383E-5*AX+0.488906E-4)*AX+0.380036E-4)*AX+0.0032776263
5      A      )*AX+0.0211410061)*AX+0.0498673469)*AX + 1.0
          F = .5 / ((F**8)**2)
10     IF ( X .GE. 0.0 ) F = 1.0 - F
          CNORM = F
10     RETURN
          END

```

EXPLANATIONS (CONTINUED)

OTHERWISE RESET MSET TO INITIAL SETTING BEFORE CONTINUING AT STATEMENT 4020 OR 9310 ACCORDING TO WHETHER CALCULATIONS HAVE OR HAVE NOT YET BEEN DONE FOR ALL THREE ANGLE VALUES OF CONCERN.

- 1380-1382 CONTINUE AT PROGRAM STATEMENT 2010 UNLESS CALCULATIONS FOR LAST RANGE HAVE JUST BEEN COMPLETED. REJECT MAY NEED TO BE RESET WHEN TARGET VULNERABILITY DATA FROM TAPE OR DISC ARE INVOLVED.
- 1383-1385 RUN STOPS, POSSIBLY PREMATURELY IF PROBLEM HAS OCCURRED.

SUBROUTINE MRAN(R1,R2) PRODUCES PAIR OF RANDOM NORMAL DEVIATES R1 AND R2 FROM NORMAL DISTRIBUTION WITH MEAN OF 0 AND STANDARD DEVIATION OF 1.

WHEN X EQUALS $(X2 - BX(N)) / SIGX(K,N)$, FOR EXAMPLE, FUNCTION CNORM(X) CALCULATES PROBABILITY OF RANDOM VARIABLE LYING BETWEEN MINUS INFINITY AND X2 FOR NORMAL DISTRIBUTION WITH BIAS OF BX(N) AND STANDARD DEVIATION OF SIGX(K,N).

APPENDIX B

EXPLANATIONS OF PROGRAM STATEMENTS 919 THROUGH 1131

EXPLANATIONS OF PROGRAM STATEMENTS 919 THROUGH 1131

This appendix contains a paper presented, in early 1979, at the Army Numerical Analysis and Computers Conference. This paper, entitled "A FORTRAN ROUTINE FOR ESTIMATING NORMAL DISTRIBUTION PARAMETERS", provides detailed explanations of program lines 919 through 1131 of the direct fire program.

The paper was subdivided into three parts, namely, the introduction, the description of the basic mathematical procedure, and the conclusion. The contents of these three parts follow.

1. INTRODUCTION. A Monte Carlo computer program simulating the engagement of a single target by a tank main armament system has been developed by the Joint Munitions Effectiveness Manual (JMEM) Methodology and Evaluations Working Group, a tri-service group responsible for establishing certain standardized estimates of weapon effectiveness. The program is often referred to as the JMEM Direct Fire program. Exercise of this program yields large amounts of data concerning the location of round impacts in the target plane. First rounds fired against a particular target are of chief concern, and these can be subdivided into rounds that hit and rounds that miss the target. Chart 1 illustrates a possible target and a few conceivable first round impact points.

This paper describes a computer routine for processing the horizontal coordinates or the vertical coordinates of hitting rounds or of missing rounds. The routine provides, for each set of data considered, an estimate of the mean and three estimates of the standard deviation for a normal distribution tentatively assumed to fit the data. After the computer run, an analyst can judge by comparing the three standard deviation values whether the tentative assumption of normality is sufficiently substantiated and, if so, make a best estimate for the parameters of interest. The word "routine" is used for the logical processing documented in this paper. However, the associated program statements have not actually been structured as a separate routine, but are a portion of the complete engagement simulation program previously mentioned. A separate routine could readily be developed for other applications.

2. DESCRIPTION OF ROUTINE. The program instructions of interest are listed in Chart 2. Note that the entire chart consists of the loop DO 7010 I = 1,2. The index I equals 1 for horizontal coordinates and 2 for vertical coordinates. For any other application, one could allow for more values of I or establish a single dummy setting for this index.

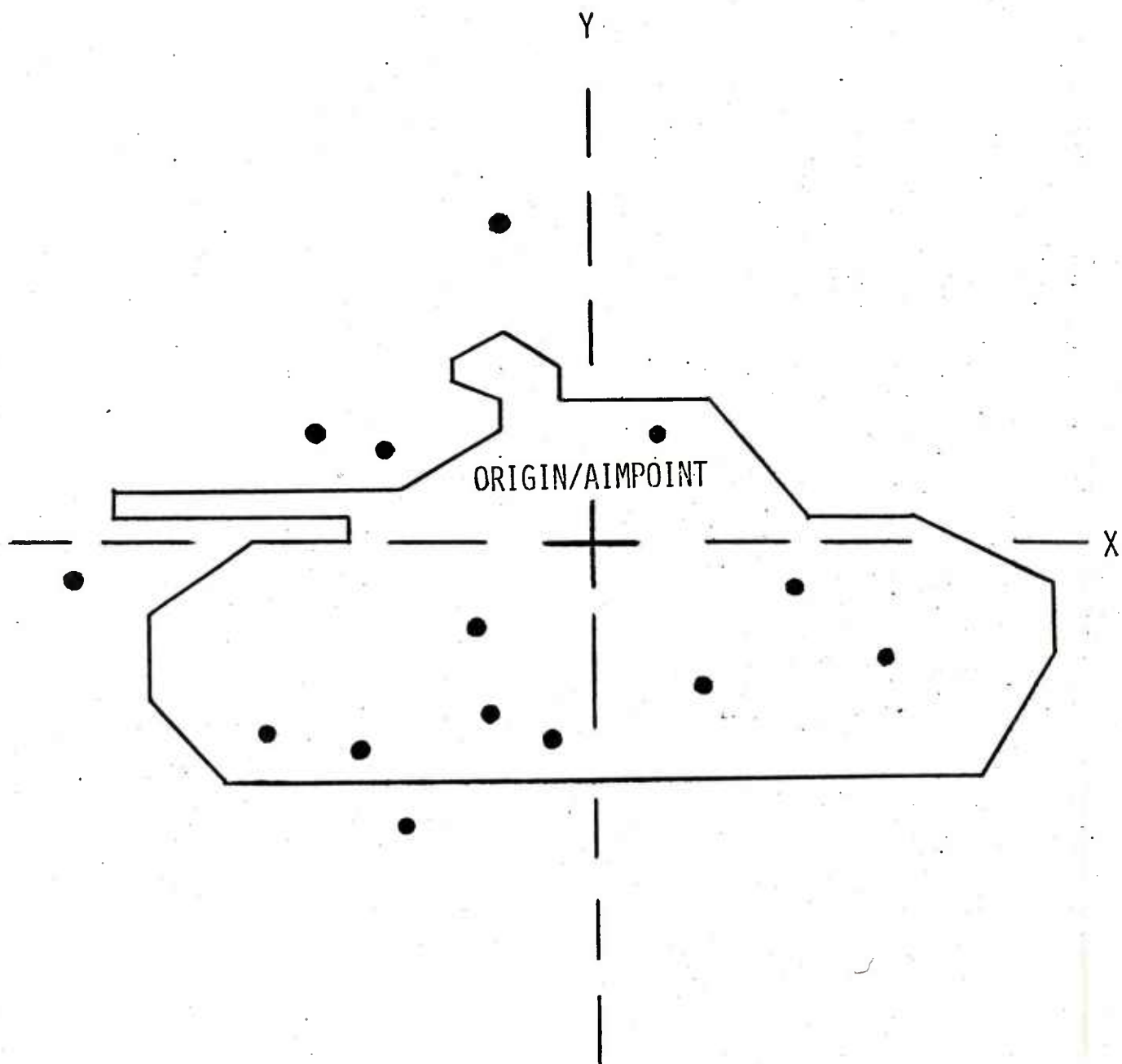


CHART 1 IMPACT POINTS FOR HITTING AND MISSING
FIRST ROUNDS

CHART 2 PROGRAM STATEMENTS

```

DO 7010 I = 1,2
AVRG = 0.0
TMINUS = 0.0
TPLUS = 0.0
KTIMES = 0
DO 7020 J = 1,50
TERM1 = NMINUS(J,I,N)
TERM2 = NPLUS(J,I,N)
TMINUS = TMINUS + TERM1
7020 TPLUS = TPLUS + TERM2
TOTAL(I) = TMINUS + TPLUS
NTOTAL = TOTAL(I)
T5000 = TOTAL(I) * 0.5
N5000 = T5000
IF ( T5000 .NE. TMINUS ) GO TO 7024
DO 7022 K = 1,50
NPOS(K) = NPLUS(K,I,N)
7022 NNEG(K) = NMINUS(K,I,N)
GO TO 7200
7024 IF ( T5000 .LT. TMINUS ) GO TO 7025
DIFF = T5000 - TMINUS
DO 7030 J = 1,50
PLUS = NPLUS(J,I,N)
IF ( PLUS .LT. DIFF ) GO TO 7035
IFRCTN = 1000.0 * DIFF / PLUS
FRCTN = FLOAT(IFRCTN) / 1000.0
AVRG = AVRG + FRCTN*20.0
JEND = 100 - KTIMES
LTIMES = 50 - KTIMES
LEND = 1 + KTIMES
DO 7040 K = 1,50
NNEG(K) = 0
7040 NPOS(K) = 0
NCMLTN = 0
NCMLTP = 0
L = 0
7050 IF ( L .EQ. 100 ) GO TO 7200
L = L + 1
LL = L
IF ( L .LE. 50 ) LL = 51 - L
M = L
IF ( L .GT. 50 ) M = L - 50
IF ( LL .LE. JEND ) GOTO 7055
NPOS(M) = 0
GO TO 7060
7055 IF ( LL .LT. JEND ) GOTO 7065
NTERM = (IFRCTN*NPLUS(50,I,N)+500) / 1000
NPOS(M) = NPLUS(50,I,N) - NTERM
NCMLTP = NCMLTP + NPOS(M)
GO TO 7060
7065 IF ( LL .LE. LTIMES ) GOTO 7075
IF ( LL .LE. 50 ) GOTO 7070

```

CHART 2 PROGRAM STATEMENTS (CONTINUED)

```

NTERM1 = (IFRCTN*NPLUS(L-LTIMES,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(L-LTIMES+1,I,N)+500) / 1000
NPOS(M) = NPLUS(L-LTIMES,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NPOS(M)
GO TO 7060
7070 NTERM1 = (IFRCTN*NPLUS(LEND-M,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(LEND-M+1,I,N)+500) / 1000
NNEG(M) = NPLUS(LEND-M,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(M)
GO TO 7060
7075 IF ( LL .LT. LTIMES ) GOTO 7085
NTERM1 = (IFRCTN*NMINUS(1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(1,I,N)+500) / 1000
NNEG(M) = NMINUS(1,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(M)
GO TO 7060
7085 IF ( LL .EQ. 1 ) GO TO 7095
NTERM1 = (IFRCTN*NMINUS(LTIMES-LL+1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(LTIMES-LL,I,N)+500) / 1000
NNEG(L-KTIMES+1) = NMINUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(L-KTIMES+1)
GO TO 7060
7095 NNEG(50) = (IFRCTN*NMINUS(49-KTIMES,I,N)+500) / 1000
NXTRA = KTIMES + 1
DO 7100 JXTRA = 1,NXTRA
7100 NNEG(50) = NNEG(50) + NMINUS(49-KTIMES+JXTRA,I,N)
NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
NNEG(50) = NNEG(50) + NTERM
NCMLTN = NCMLTN + NNEG(50)
7060 IF ( NCMLTP .EQ. NTOTAL ) L = 100
IF ( L .GT. 50 ) GO TO 7050
IF ( NCMLTN .LT. N5000 ) GO TO 7050
NCMLTP = NCMLTN
L = 50
GO TO 7050
7035 DIFF = DIFF - PLUS
KTIMES = KTIMES + 1
AVRG = AVRG + 20.0
7030 CONTINUE
7025 DIFF = TMINUS - T5000
DO 7110 J = 1,50
AMINUS = NMINUS(J,I,N)
IF ( AMINUS .LT. DIFF ) GO TO 7115
IFRCTN = 1000.0 * DIFF / AMINUS
FRCTN = FLOAT(IFRCTN) / 1000.0
AVRG = AVRG - FRCTN*20.0
JEND = 100 - KTIMES
LTIMES = 50 - KTIMES
LEND = 1 + KTIMES
DO 7120 K = 1,50
NPOS(K) = 0
7120 NNEG(K) = 0
NCMLTP = 0
NCMLTN = 0
L = 0
7130 IF ( L .EQ. 100 ) GO TO 7200
L = L + 1

```

CHART 2 PROGRAM STATEMENTS (CONTINUED)

```

LL = L
IF ( L .LE. 50 ) LL = 51 - L
M = L
IF ( L .GT. 50 ) M = L - 50
IF ( LL .LE. JEND ) GOTO 7135
NNEG(M) = 0
GO TO 7140
7135 IF ( LL .LT. JEND ) GOTO 7145
NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
NNEG(M) = NMINUS(50,I,N) - NTERM
NCMLTN = NCMLTN + NNEG(M)
GO TO 7140
7145 IF ( LL .LE. LTIMES ) GOTO 7155
IF ( LL .LE. 50 ) GOTO 7150
NTERM1 = (IFRCTN*NMINUS(L-LTIMES,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(L-LTIMES+1,I,N)+500) / 1000
NNEG(M) = NMINUS(L-LTIMES,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(M)
GO TO 7140
7150 NTERM1 = (IFRCTN*NMINUS(LEND-M,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(LEND-M+1,I,N)+500) / 1000
NPOS(M) = NMINUS(LEND-M,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NPOS(M)
GO TO 7140
7155 IF ( LL .LT. LTIMES ) GOTO 7165
NTERM1 = (IFRCTN*NPLUS(1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(1,I,N)+500) / 1000
NPOS(M) = NPLUS(1,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NPOS(M)
GO TO 7140
7165 IF ( LL .EQ. 1 ) GO TO 7175
NTERM1 = (IFRCTN*NPLUS(LTIMES-LL+1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(LTIMES-LL,I,N)+500) / 1000
NPOS(L-KTIMES+1) = NPLUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NPOS(L-KTIMES+1)
GO TO 7140
7175 NPOS(50) = (IFRCTN*NPLUS(49-KTIMES,I,N)+500) / 1000
NXTRA = KTIMES + 1
DO 7180 JXTRA = 1,NXTRA
7180 NPOS(50) = NPOS(50) + NPLUS(49-KTIMES+JXTRA,I,N)
NTERM = (IFRCTN*NPLUS(50,I,N)+500) / 1000
NPOS(50) = NPOS(50) + NTERM
NCMLTP = NCMLTP + NPOS(50)
7140 IF ( NCMLTN .EQ. NTOTAL ) L = 100
IF ( L .GT. 50 ) GO TO 7130
IF ( NCMLTP .LT. N5000 ) GO TO 7130
NCMLTN = NCMLTP
L = 50
GO TO 7130
7115 DIFF = DIFF - AMINUS
KTIMES = KTIMES + 1
AVRG = AVRG - 20.0
7110 CONTINUE
7200 CONTINUE
DO 7310 K = 1,50
IF ( K .GT. 1 ) GO TO 7315
NSUM1 = NPOS(K)

```


CHART 2 PROGRAM STATEMENTS (CONTINUED)

```

NSUM2 = NNEG(K)
GO TO 7320
7315 NSUM1 = NSUM1 + NPOS(K)
NSUM2 = NSUM2 + NNEG(K)
7320 NCMPOS(K) = NSUM1
NCMNEG(K) = NSUM2
NRFLCT(K) = NSUM1 + NSUM2
7310 CONTINUE
DO 7330 J = 1,50
SIGMAX = J * 20
IF ( J .GT. 1 ) GO TO 7335
SMFRQ1 = 0.0
SMFRQ2 = NRFLCT(1) * 10000 / NTOTAL
K5 = 5
K10 = 10
GO TO 7350
7335 SMFRQ1 = SMFRQ2
IF ( J .EQ. 50 ) GO TO 7345
SMFRQ2 = NRFLCT(J) * 10000 / NTOTAL
GO TO 7350
7345 SMFRQ2 = 10000.0
7350 FRQNCY = SMFRQ2 - SMFRQ1
IF ( K5 .NE. 5 ) GO TO 7355
IF ( SMFRQ2 .LT. 3829.2 ) GOTO 7330
D05 = (SMFRQ2-3829.2) / FRQNCY
SIG05 = (SIGMAX-D05*20.0) / 0.5
K5 = 0
7355 IF ( K10 .NE. 10 ) GO TO 7365
IF ( SMFRQ2 .LT. 6826.8 ) GOTO 7330
D10 = (SMFRQ2-6826.8) / FRQNCY
SIG10 = SIGMAX - D10*20.0
K10 = 0
7365 IF ( SMFRQ2 .LT. 8663.8 ) GOTO 7330
D15 = (SMFRQ2-8663.8) / FRQNCY
SIG15 = (SIGMAX-D15*20.0) / 1.5
GO TO 7370
7330 CONTINUE
7370 WRITE ( 6,1020 )
WRITE ( 6,7380) N,I,SIG05,SIG10,SIG15
7380 FORMAT ( 10X,26H N,I,SIG05,SIG10,SIG15 ,2I10,3F10.4 )
BIASXY(I,N) = AVRG
IF ( I .EQ. 1 ) SSQRRE = SIGXL**2 + SIGXR**2
IF ( I .EQ. 2 ) SSQRRE = SIGYL**2 + SIGYR**2
SIGMXY(1,I,N) = SQRT(SIG05**2+SSQRRE)
SIGMXY(2,I,N) = SQRT(SIG10**2+SSQRRE)
SIGMXY(3,I,N) = SQRT(SIG15**2+SSQRRE)
7010 CONTINUE

```

The index N is set before the DO 7010 loop and presently has possible values of 1 through 5. N equals 1 when hitting first rounds are of concern and 3 for missing first rounds. Meanings of the values 2, 4, and 5 need not be explained here. The range of values of N can, for other applications, be increased or decreased; in particular, a single dummy setting can be used.

The horizontal and vertical coordinate axes are each subdivided into 100 intervals of 20 inches each; positive and negative coordinates are each covered by 50 intervals. Intervals are related to the index J in a way that should soon be clear. Assume that one has run many simulated engagements and determined, for hitting rounds and missing rounds separately, how many times a particular interval contained the horizontal coordinate of the first round and, again separately, the vertical coordinate. Input data of this sort are shown in Chart 3. Numbers in the array NPLUS(J,I,N) indicate how many coordinates are within the interval 0 to 20 inches for J = 1, within the interval 20 to 40 inches for J = 2, and so forth. Similarly, the NMINUS(J,I,N) array contains the number of coordinates within the interval -20 to 0 inches for J = 1, and so forth.

The arrays involved in Chart 2 and their dimensions in the JMEM Direct Fire program are as follows:

```
NMINUS(50,2,5)
NPLUS(50,2,5)
TOTAL(2)
NNEG(50)
NPOS(50)
NCMPOS(50)
NCMNEG(50)
NRFLCT(50)
```

The NMINUS and NPLUS arrays contain the data to be processed.

The complete calculations for particular values of N and I yield an estimate of the mean, denoted by AVRGE, and three estimates of the standard deviation, represented by SIG05, SIG10, and SIG15.

A total of 1000 engagements were simulated to obtain the data in Chart 3. A first round hit was obtained in 529 instances, and the first round missed the target in the other 471 instances. The impact points for the 529 hits were (for an observer at the firing weapon) to the right of the Y-axis illustrated in Chart 1 on 324 occasions, and to the left on the other 205 occasions. These same impact points were above the X-axis 198 times and below 331 times. Impact points of the 471 misses had positive horizontal coordinates in 278 engagements, and positive vertical coordinates in 369 engagements. To illustrate the remainder of these explanations, an arbitrary choice has been made of the values N = 3 (missing first rounds) and I = 2 (vertical coordinates).

It is useful to digress and consider how the mean and standard deviation of a normal distribution corresponding to the input data selected can be estimated graphically. Chart 4 shows the associated quantitative basis and Chart 5 the plotted points to which one would attempt, using judgement rather than calculation, to fit a straight line. The computer routine being described performs computations that basically parallel the graphical approach.

CHART 3 SAMPLE INPUT DATA

		<u>N = 1</u> <u>I = 1</u>	<u>N = 1</u> <u>I = 2</u>	<u>N = 3</u> <u>I = 1</u>	<u>N = 3</u> <u>I = 2</u>
		(205)	(331)	(193)	(102)
8		0	0	0	0
7		0	0	0	0
6		0	0	0	3
5		2	1	0	14
4		11	17	12	29
3		34	50	21	19
2		65	118	59	17
1		93	145	101	20
1	0-20	140	109	96	71
2	20-40	100	71	81	104
3	ETC	55	17	54	104
4		21	1	35	58
5		8	0	8	19
6		0	0	2	11
7		0	0	2	2
8		0	0	0	0
		(324)	(198)	(278)	(369)
		(529)	(529)	(471)	(471)

CHART 4 BASIS FOR CHART 5

N=3, I=2

			CUMULATIVE SUM	CUMULATIVE FRACTION (SUM/471)
J	NMINUS (J, I, N)	6 3	3	.006
		5 14	17	.04
		4 29	46	.10
		3 19	65	.14
		2 17	82	.17
		1 20	102	.22
		1 71	173	.37
	NPLUS (J, I, N)	2 104	277	.59
		3 104	381	.81
		4 58	439	.93
		5 19	458	.97
		6 11	469	.996
		7 2	471	1.000

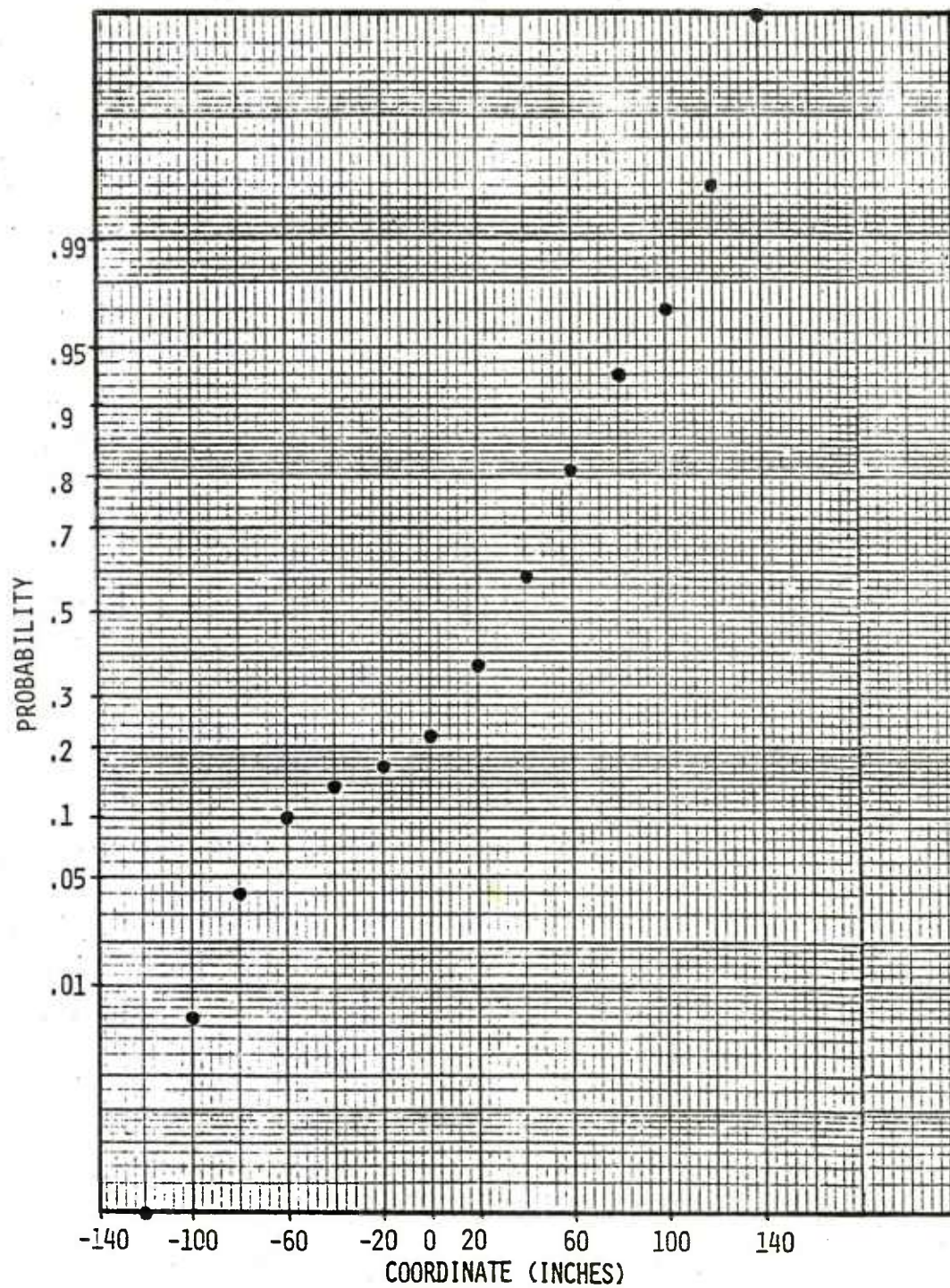


CHART 5 DISTRIBUTION OF COORDINATE DATA

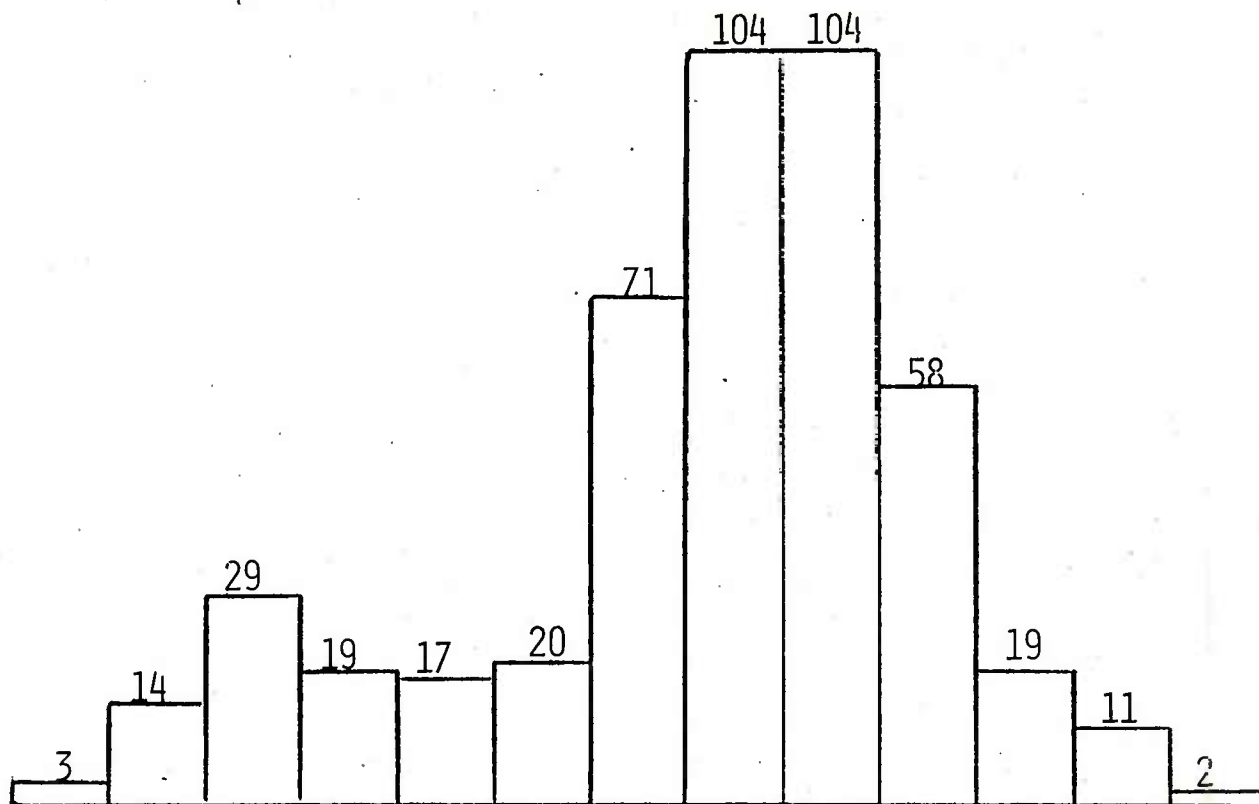
The steps involved in estimating the mean are illustrated in Chart 6. Note that, for this example, the nonzero input data of concern are $NPLUS(1,I,N) = 71$, $NPLUS(2,I,N) = 104$, . . . , $NPLUS(7,I,N) = 2$, $NMINUS(1,I,N) = 20$, . . . , $NMINUS(6,I,N) = 3$. The totals 102 and 369 are the values of $TMINUS$ and $TPLUS$ after completion of the DO 7020 loop. Since $TPLUS$ exceeds $TMINUS$, the program attempts to identify a positive value on the Y-axis as the estimate of the mean. Consequently, $DIFF$ is calculated by the statement right before the DO 7030 loop, rather than by the statement preceding the DO 7110 loop. The DO 7030 loop establishes first that the point of central tendency is at least as great as 20 inches, the right end of the first interval considered. This is so because 133 impact point coordinates need to be dropped from the $NPLUS$ group before the coordinates equal half of $NTOTAL$. Since the 71 coordinates in $NPLUS(1,I,N)$ are less than 133, $KTIMES$ is reset to 1 and the difference is reduced to 62. Next, the DO 7030 loop determines that .6 of the 104 coordinates in the interval 20 to 40 inches need to be dropped. Since .6 times 20 equals 12, the points to be dropped are simply assumed to be located in the interval 20 to 32 inches, while all other points in the interval 20 to 40 inches are considered to exceed 32. One can observe in Chart 7 that the calculated value of $AVRG$ corresponds to the point where one of the line segments joining adjacent points crosses the .5 probability level.

Once the mean is known, the next step is to relate the original input data to a new set of 20-inch intervals centered about the mean. Chart 8 illustrates how this is done. Each $NMINUS(J,I,N)$ and $NPLUS(J,I,N)$ value is first subdivided into two subelements according to the value of $FRCTN$. For example, $NMINUS(6,I,N)$ is broken up into 2, associated with the 12 inches to the left, and 1, considered in the right 8 inches of the interval -100 to -120 inches. Subelements from adjacent intervals are then paired appropriately and added to get $NNEG(M)$ and $NPOS(M)$ values, where the index M is associated with the adjusted set of intervals. Note how $NPLUS(2,I,N)$, which involves the original interval containing the estimated mean 32, contributes 62 to $NNEG(1)$ and 42 to $NPOS(1)$. The cumulative totals $MCMLTN$ and $NCMLTP$, where $NCMLTP$ always includes the maximum value of $NCMLTN$, enable the computer to determine when all the original nonzero input information has been processed. The interval adjustment just described is done by the statements beginning with $JEND = 100 - KTIMES$ that follow the final determination of $AVRG$ in the DO 7030 loop, or in the DO 7110 loop.

After the interval adjustment calculations have been completed, the DO 7310 loop of the program computes the values in the $NRFLCT$ array as shown in Chart 9. The $NRFLCT$ array represents an equal weight combination of the $NPOS$ and $NNEG$ data. Any $NRFLCT(K)$ value indicates how often the absolute values of the differences between the vertical coordinates of missing first rounds and the estimated mean are equal to or less than $20 K$ inches. The fractions obtained when one divides the $NRFLCT$ values by $NTOTAL$ are not calculated by the program, but are included in Chart 9. Chart 10 illustrates how these fractions are related to the distribution of concern.

The DO 7330 loop determines the three alternative estimates for the standard deviation. These estimates are based on the probabilities associated in a normal distribution with the mean plus or minus 0.5 standard deviation, plus or minus 1.0 standard deviation, and plus or minus 1.5 standard deviation. Linear interpolation is applied, as necessary, to the distribution implied by the $NRFLCT$ values to infer estimates of 0.5, 1.0, and 1.5 times the standard

CHART 6 CALCULATION OF MEAN



TMINUS = 102.

TPLUS = 369.

NTOTAL = 471

N5000 = 235

DIFF = 133.

71. < 133.

KTIMES = 1

DIFF = 62.

104. > 62.

FRCTN = .6

AVRG = 32.0

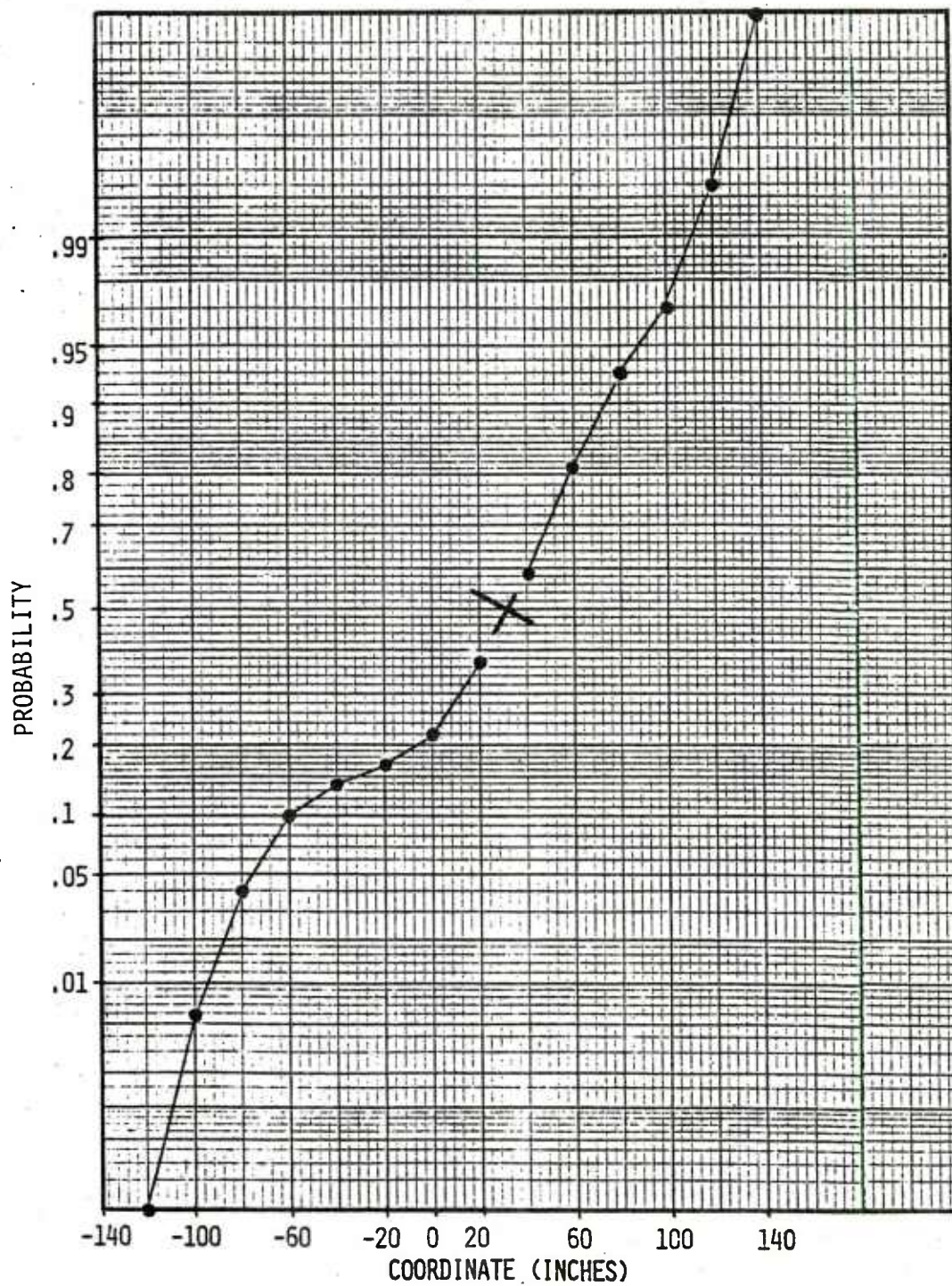


CHART 7 ESTIMATED MEAN (AVRG)

CHART 8 ADJUSTMENT OF INTERVALS

N=3, I=2

7	0	0	0	2	8	235
6	3 x .6	2	1	9	7	233
5	14 x .6	8	6	23	6	224
4	29 ETC	17	12	23	5	201
3	19	11	8	18	4	178
2	17	10	7	19	3	160
1	20	12	8	51	2	141
1	71	43	28	90	1	90
2	104	62	42	104	1	339
3	104	62	42	77	2	416
4	58	35	23	34	3	450
5	19	11	8	15	4	465
6	11	7	4	5	5	470
7	2	1	1	1	6	471
8	0	0	0			

CHART 9 CALCULATION OF NRFLCT AND
CORRESPONDING FRACTIONS

8	2	235		
7	9	233		
6	23	224		
5	23	201		
4	18	178		
3	19	160		
2	51	141		
1	90	90		
K				<u>NRFLCT(K)/471</u>
1	104	104	194	.412
2	77	181	322	.684
3	34	215	375	.796
4	15	230	408	.866
5	5	235	436	.926
6	1	236	460	.977
7	0	236	469	.996
8	0	236	471	1.000

- POINTS AS IN CHART 5
- POINTS BASED ON NRFLCT ARRAY

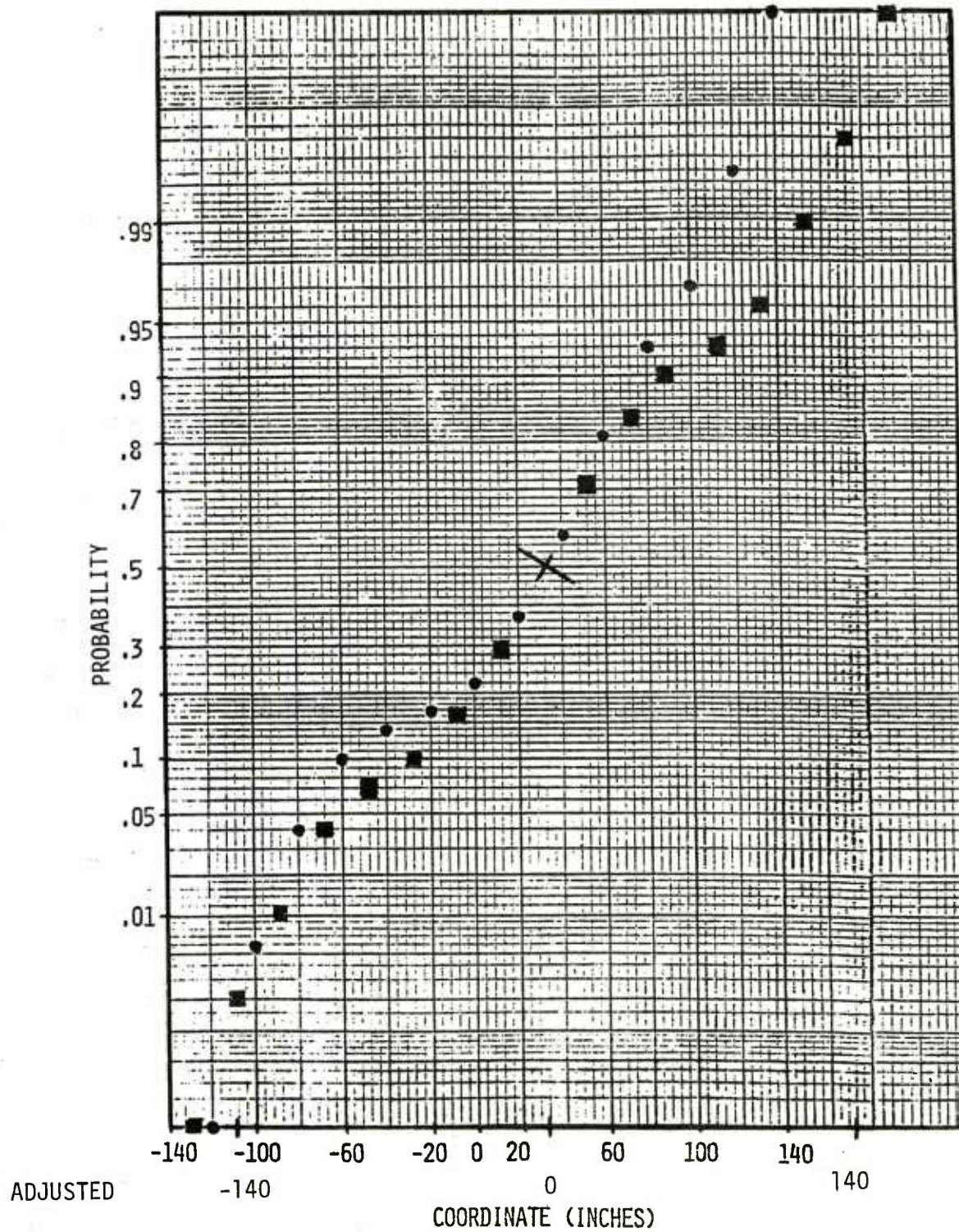


CHART 10 FRACTIONS BASED ON NRFLCT VALUES

- POINTS AS IN CHART 5
- POINTS BASED ON NRFLCT ARRAY

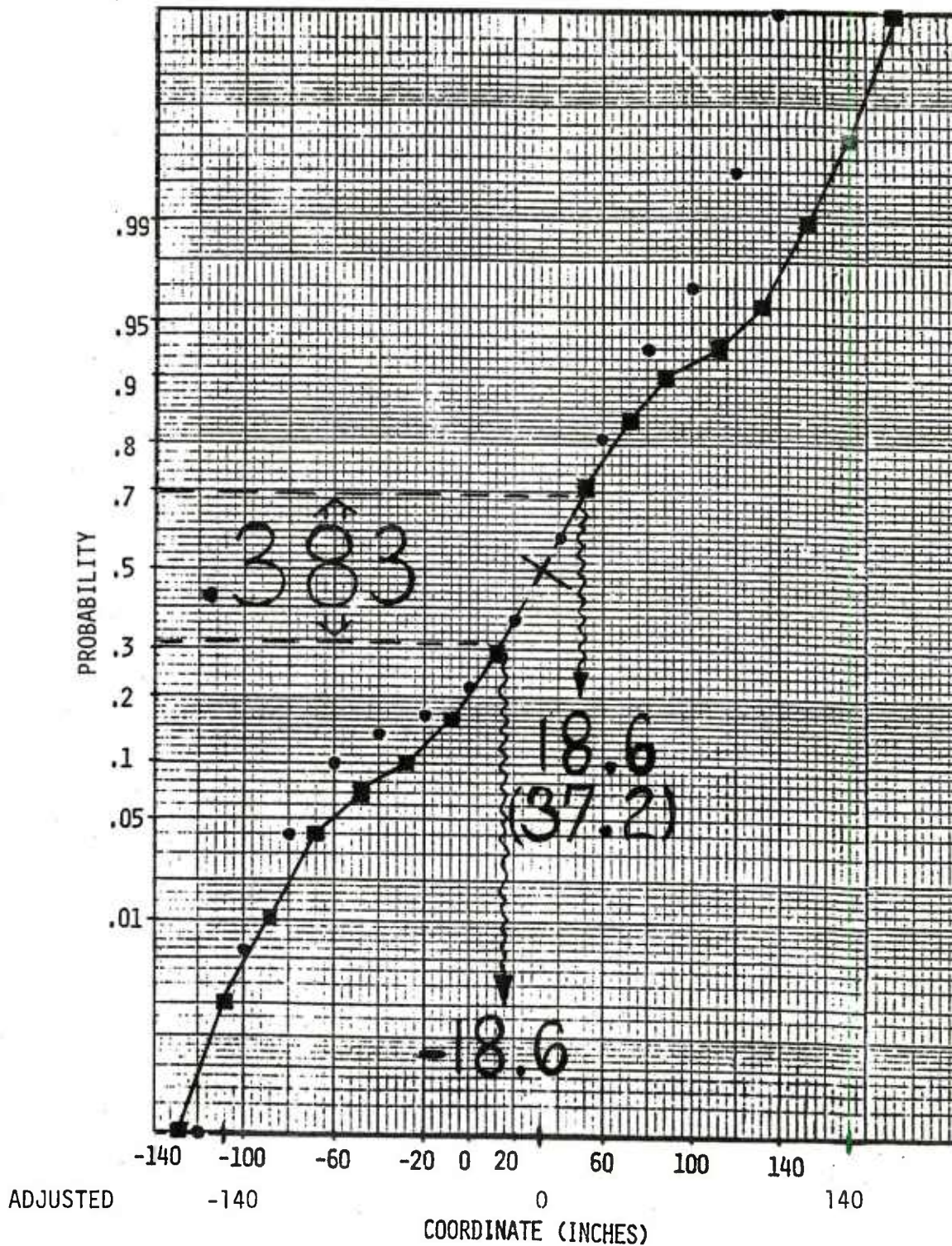


CHART 11 ESTIMATE OF 0.5 STANDARD DEVIATION

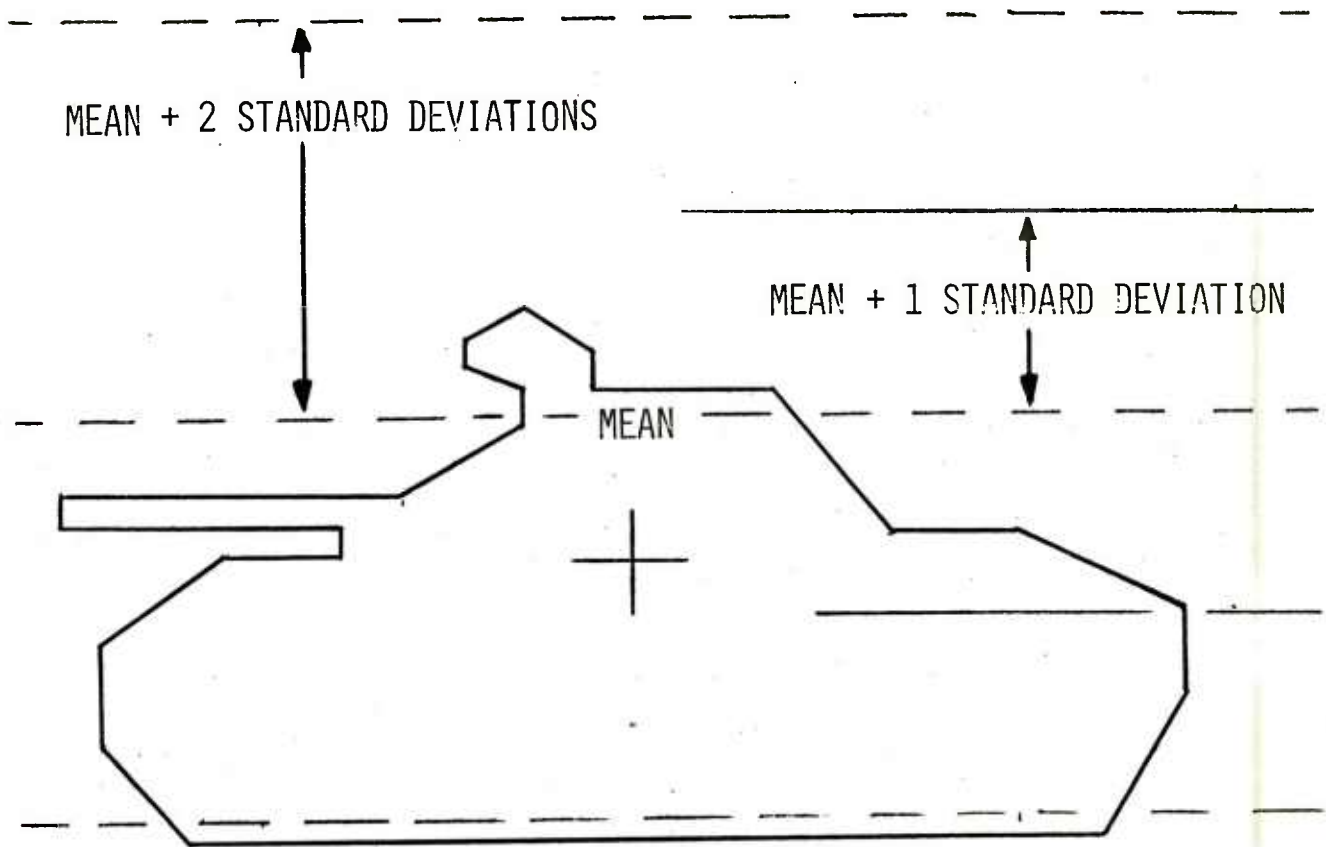


CHART 12 ILLUSTRATION OF DISTRIBUTION FOR MEAN OF
32 INCHES AND STANDARD DEVIATION OF 40 INCHES

deviation. For example, as is shown in Chart 11, a frequency of .383 is associated with the mean plus or minus 0.5 standard deviation. Vertical lines through $.5 - (.383/2)$, which equals about .31, and through $.5 + (.383/2)$, approximately .69, cross line segments joining points based on the NRFLCT array at intersections that correspond to adjusted horizontal scale values of -18.6 and 18.6 inches. The related standard deviation estimate is 37.2 inches. Similarly, standard deviation estimates based on 1.0 and 1.5 times the standard deviation turn out to be 39.9 and 53.4 inches respectively.

3. CONCLUSION. Consider again the context within which arose the need for the procedure explained in this paper. Chart 12 illustrates the information concerning the vertical coordinates of missing first rounds that is conveyed by the calculated mean and a standard deviation estimate of 40 inches, selected as a best estimate for the particular situation used as an illustrative example in this paper.

Next page is blank.

DISTRIBUTION LIST

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
12	Commander The Defense Technical Information Center ATTN: TCA Cameron Station Alexandria, VA 22314	1	Commander US Army Training & Doctrine Comd ATTN: ATCD-AO-C FT Monroe, VA 23651
1	Commander US Army Materiel Development & Readiness Command ATTN: DRCPA-S 5001 Eisenhower Avenue Alexandria, VA 22333	1	Commander US Army Training & Doctrine Comd ATTN: ATTNG-TDD-OR FT Monroe, VA 23651
1	Commander US Army Materiel Development & Readiness Command ATTN: DRCBSI-L 5001 Eisenhower Avenue Alexandria, VA 22333	1	Commander US Army Tank-Automotive R&D Comd ATTN: DRSTA-RPL (Tech Lib) Warren, MI 48090
1	Commander US Army Materiel Development & Readiness Command ATTN: DRCGS-L 5001 Eisenhower Avenue Alexandria, VA 22333	1	Commander US Army Tank-Automotive R&D Comd ATTN: DRDTA-V (Mr. Nouse) Warren, MI 48090
1	Commander US Army Materiel Development & Readiness Command ATTN: DRCGS-L 5001 Eisenhower Avenue Alexandria, VA 22333	1	Commander US Army Tank-Automotive R&D Comd ATTN: DRDTA-RHMM (Mr. Thompson) Warren, MI 48090
1	HQDA (SAUS-OR/Mr. Woodall) WASH DC 20310	1	Director Defense Nuclear Agency ATTN: VLWS Washington, DC 20305
1	HQDA (DAMO-ZD) WASH DC 20310	1	Director Defense Nuclear Agency ATTN: TITL Washington, DC 20305
1	HQDA (DAMO-RQD) WASH DC 20310	1	Project Manager XM1 Tank System ATTN: DRCPA-GCM-S (Mr. R. Patek) 38111 Van Dyke Avenue Warren, MI 48090
1	Office of Secretary of Defense ODDR&E (Mr. F. Horton) Washington, DC 20310		
1	Commander US Army Training & Doctrine Comd ATTN: ATCD-CM-A FT Monroe, VA 23651	1	Commander US Army Tank Automotive Materiel Readiness Command ATTN: DRCPM-M60 Warren, MI 48090

DISTRIBUTION LIST - Continued

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
1	Commander US Army Armor Ctr & FT Knox ATTN: ATZK-CD-TS FT Knox, KY 40121	1	Commander US Army Armament R&D Command ATTN: DRDAR-TSS Dover, NJ 07801
1	Commander US Army Armor Ctr & FT Knox ATTN: ATZK-AE-CV FT Knox, KY 40121	1	Commander US Army Armament R&D Command ATTN: DRDAR-LCS (Mr. Einbinder) Dover, NJ 07801
1	Commander US Army Armor Ctr & FT Knox ATTN: ATZK-CD-MS (Mr. Falkovich) FT Knox, KY 40121	1	Commander US Army Armament R&D Command ATTN: DRDAR-SCS-M (Mr. Gaydos) Dover, NJ 07801
1	Commander US Army Armor Ctr & FT Knox ATTN: ATZK-CD-SD (Mr. Hilkemeyer) FT Knox, KY 40121	1	Commander US Army Armament Materiel Readiness Command ATTN: DRSAR-LEP-L (Tech. Lib.) Rock Island, IL 61201
1	Commander US Army Concepts Anal Agcy ATTN: Library 8120 Woodmont Avenue Bethesda, MD 20014	1	Commander US Army Armament Materiel Readiness Command ATTN: DRSAR-PES (Mr. Michels) Rock Island, IL 61201
1	Commander US Army Concepts Anal Agcy ATTN: MOCA-MRA (Mr. Thomas) 8120 Woodmont Avenue Bethesda, MD 20014	1	Commander US Army Electronics R&D Command ATTN: DRDEL-AP-0A 2800 Powder Mill Road Adelphi, MD 20783
1	Commander US Army Armament R&D Command ATTN: DRDAR-LCU-CT (Mr. Barrieres) Dover, NJ 07801	1	Director Institute for Defense Analysis ATTN: Documents Library 400 Army-Navy Drive Arlington, VA 22202
1	Commander US Army Armament R&D Command ATTN: DRDAR-LCN-DP (Mr. Botti) Dover, NJ 07801	1	Director Defense Advanced Rsch Proj Agcy ATTN: TTO (Mr. Lehner) 1400 Wilson Blvd. Arlington, VA 22209

DISTRIBUTION LIST - Continued

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
1	Marine Corps Operations Analysis Group ATTN: Mr. Love 2000 North Beauregard St. Alexandria, VA 22311	1	Commander US Army Combat Developments Experimentation Command ATTN: Technical Library FT Ord, CA 93941
1	Marine Corps Operations Analysis Group ATTN: Document Ctr (Dr. Simmons) 2000 North Beauregard St. Alexandria, VA 22311	3	Director US Army TRADOC Sys Anal Act ATTN: ATAA-SA White Sands Msl Rg, NM 88002
1	Commandant US Coast Guard ATTN: G-OMR-2B/33 2100 2nd St., S.W. Washington, DC 20593	1	Director US Army TRADOC Sys Anal Act ATTN: ATAA-TF (Mr. Curl) White Sands Msl Rg, NM 88002
1	Commander US Army Intelligence Analysis Center ATTN: IAX-OT-P (Mr. Alston) Arlington Hall Station Arlington, VA 22212	1	Director US Army TRADOC Sys Anal Act ATTN: ATAA-TEA (Mr. Burnham) White Sands Msl Rg, NM 88002
1	Commander Naval Weapons Center ATTN: Code 40701 (Mr. Melvin Keith) China Lake, CA 93555	1	Director US Army TRADOC Sys Anal Act ATTN: ATAA-T White Sands Msl Rg, NM 88002
1	Reliability Analysis Center ATTN: Mr. I.L. Krulac Griffiss AFB, NY 13441	1	Commander US Army Combined Arms Combat Developments Activity ATTN: Library FT Leavenworth, KS 66027
2	Chief Defense Logistics Studies Information Exchange US Army Logistics Mgnt Ctr ATTN: DRXMC-D FT Lee, VA 23801	1	Commander US Army Combined Arms Combat Developments Activity ATTN: ATCA-CFD FT Leavenworth, KS 66027
1	Commander US Army Infantry Center ATTN: ATSH-CD-CS FT Benning, GA 31905		

DISTRIBUTION LIST - Continued

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
1	Commander US Army Combined Arms Combat Developments Activity ATTN: ATCA-CAM-V FT Leavenworth, KS 66027	1	Commander US Army Logistics Eval Agcy ATTN: COL Walker New Cumberland Army Depot New Cumberland, PA 17070
1	Commander US Army Combined Arms Training Developments Activity ATTN: ATZL-TDA-DSA FT Leavenworth, KS 66027	1	Commander US Army Foreign Science & Technology Center ATTN: DRXST-CA3 (Mr. Bollendcrf) 220 7th Street, NE Charlottesville, VA 22901
1	Commander TRADOC Combined Arns Test Agcy ATTN: ATCAT-TD-CON FT Hood, TX 76544	1	Commander-In-Chief Research Analysis Office Box 13, J77 ATTN: Mike Mulhern Camp H.M. Smith, Hawaii 96861
1	Commander TRADOC Combined Arms Test Agcy ATTN: Library FT Hood, TX 76544	1	Commandant Command & General Staff College ATTN: Technical Library FT Leavenworth, KS 66027
1	Commander US Army Mobility Equipment R&D Command ATTN: ORDME-O (B. Briggs) FT Belvoir, VA 22060	1	Commandant US Army War College ATTN: Library R-1069 Carlisle Barracks, PA 17013
1	Commandant US Army Field Artillery School ATTN: ATSF-CD-DA (J. Horn) FT Sill, OK 73503	1	Commandant US Army Air Defense School Director for Combat Developments ATTN: Mr. Don Vance FT Bliss, TX 79916
1	Commandant US Army Field Artillery School ATTN: ATSF-CD-MS (Mr. Minton) FT Sill, OK 73503	1	US Army Training Systems Center Training Devices Directorate ATTN: ATTSC-TD FT Eustis, VA 23604
5	Commander US Army Operation Test & Evaluation Agency ATTN: CSTE-ED 5600 Columbia Pike Falls Church, VA 22041	1	Director US Army Electronics Warfare Lab ATTN: DELEW-P FT Monmouth, NJ 07703

DISTRIBUTION LIST - Continued

<u>No. of Copies</u>	<u>Organization</u>
1	Commander Naval Surface Weapons Center ATTN: Code G-31 (Mr. G. Seidl) Dahlgren, VA 22448
1	Commander Naval Surface Weapons Center ATTN: Code DG-14 (Mr. G. Hornbaker) Dahlgren, VA 22448
1	Oklahoma State University Field Office ATTN: A. Peebles PO Box 1925 Eglin AFB, FL 32542 <u>Aberdeen Proving Ground, MD</u>
1	Director, USABRL Bldg. 328
1	Director, USABRL ATTN: DRDAR-TSB-S Bldg. 305
1	Director, USAHEL Bldg. 520
1	Commander, USATECOM ATTN: DRSTE-CM-F Bldg. 314